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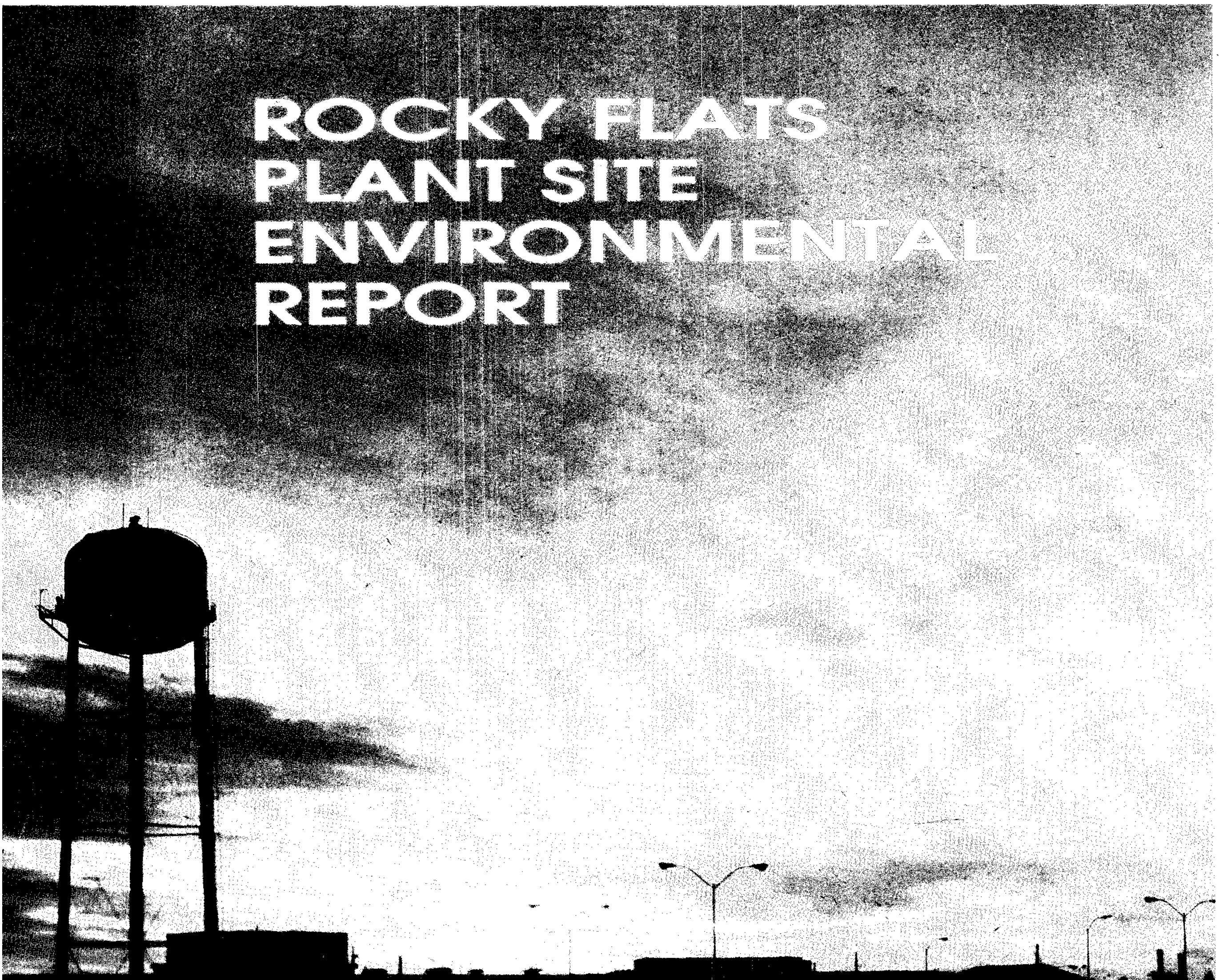
ROCKY FLATS PLANT SITE ENVIRONMENTAL REPORT



EG&G ROCKY FLATS

JANUARY THROUGH DECEMBER 1991

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ROCKY FLATS PLANT SITE ENVIRONMENTAL REPORT FOR 1991

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PREFACE

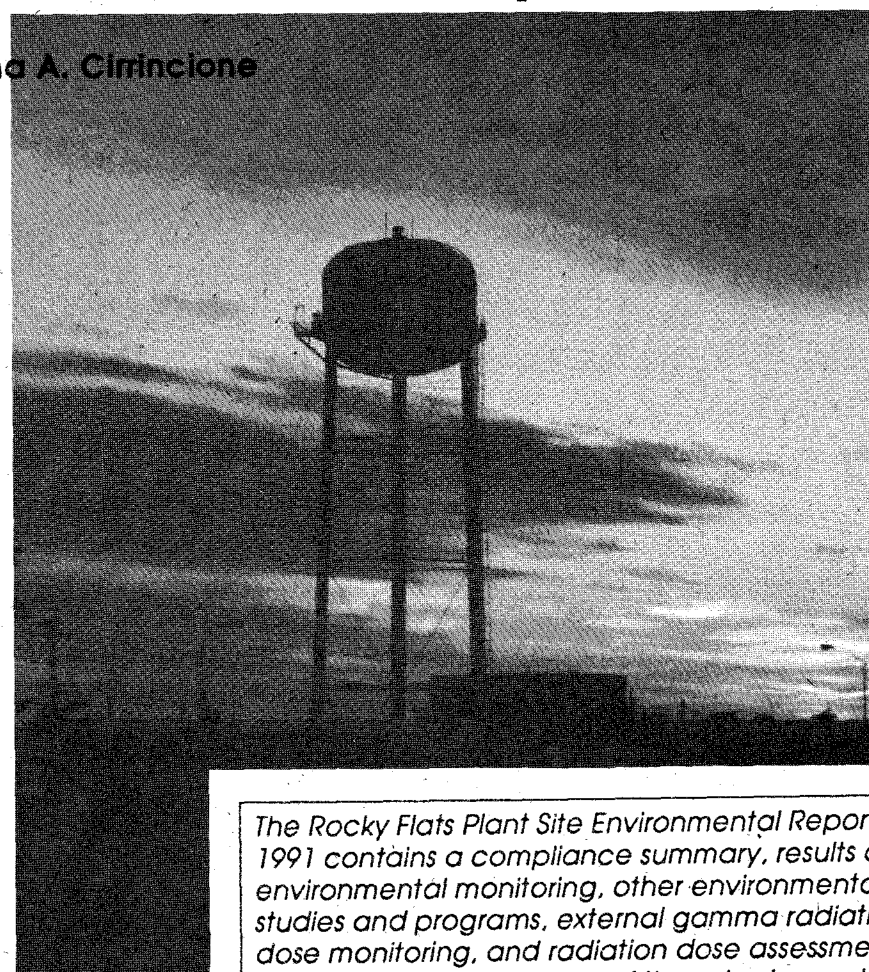
This report provides information to the public about the impact of the Rocky Flats Plant on the environment and public health. The report contains a compliance summary, a description of environmental monitoring programs, and radiation dose estimates for the surrounding population for the period January 1 through December 31, 1991. Currently, general content and format for this report are specified by Department of Energy Order 5400.1.

An environmental surveillance program has been ongoing at the Rocky Flats Plant since the 1950s. Early programs focused on radiological impacts to the environment. The current program not only examines potential impacts to air, surface water, groundwater, and soils from radiological and nonradiological sources, but also includes ecological studies and environmental remediation programs.

Environmental operations at Rocky Flats Plant are under the jurisdiction of several local, state, and federal agencies, most notably the Colorado Department of Health, Environmental Protection Agency, and Department of Energy. A variety of reports are prepared at different intervals for these and other agencies in addition to the annual environmental report. A list of these reports is given in Section 3, Table 3-1.

Executive Summary

Dianna A. Cirrincione



The Rocky Flats Plant Site Environmental Report for 1991 contains a compliance summary, results of environmental monitoring, other environmental studies and programs, external gamma radiation dose monitoring, and radiation dose assessments. This section is an overview of these topics and summarizes more comprehensive discussions found in the main text of the report.

COMPLIANCE SUMMARY

National Environmental Policy Act (NEPA)

A Notice of Intent (NOI) for the Plutonium Recovery Modification Project Environmental Impact Statement (PRMP EIS) was published in the *Federal Register* on May 30, 1990. Public scoping meetings were held on June 18 and 20, 1990, followed by a 45-day comment period. A draft Implementation Plan for the PRMP EIS was completed in November 1991.

The NOI for the Programmatic Environmental Impact Statement (PEIS) on the Integrated Environmental and Waste Management Program was published in the *Federal Register* on October 22, 1990. A public scoping meeting was held on January 23, 1991, and an Implementation Plan is under development.

The NOI for a Rocky Flats Plant (RFP) Sitewide EIS was published in the *Federal Register* on March 13, 1991. Public scoping meetings were held on April 4, 8, and 11, 1991; comments were accepted through April 19, 1991.

The Environmental Assessment (EA) for the Interim Remedial Action/Environmental Assessment for Operable Unit 2 (OU 2) (903 Pad, Mound, and East Trenches Areas) was prepared. A Finding of No Significant Impact (FONSI) for this proposed action was received on March 7, 1991.

Preparation of an EA for the Dewatering and Resource Conservation and Recovery Act (RCRA) Partial Closure Action on Solar Evaporation Ponds began in 1990. The EA was approved on February 21, 1991, and a FONSI was received on June 17, 1991. A Notice of Availability was published on August 9, 1991.

Development of EAs were initiated for five additional facilities/operations in 1991 and are in various stages of preparation and review.

Endangered Species Act, Fish and Wildlife Coordination Act, Migratory Bird Treaty Act, and Executive Order 11990 (Protection of Wetlands)

On August 23, 1991, a public Notice of Wetland Involvement was published in the *Federal Register* according to Code of Federal Regulations 10CFR1022. Biological survey and habitat reports were prepared for the South Interceptor Ditch and 881 Hillside French Drain in October and November 1991, respectively.

Clean Air Act (CAA)

The Environmental Protection Agency's (EPA) National Emissions Standards for Hazardous Air Pollutants (NESHAPs) set a yearly limit of 10 millirem per year (mrem/yr) effective dose equivalent (EDE) to any member of the public. Radionuclide air emissions from RFP are within the required limits.

The RFP's radionuclide emissions monitoring systems are not in full compliance with EPA's monitoring requirements; however, the existing monitoring deficiencies are not likely to cause emissions to be underestimated. RFP is responding to a Compliance Order (issued to RFP by EPA Region VIII) that requires compliance with the effluent monitoring requirements of 40CFR61.93(b).

The calculated beryllium discharged from RFP in 1991 was 7.1 grams (g), compared to the daily stationary source limit of 10 g over a 24-hr period set by Colorado Air Quality Control Regulation #8.

RFP submitted Air Pollutant Emission Notices (APENs) to the Colorado Department of Health (CDH) for 97 process and support buildings. APENs are required by Colorado Air Quality Control Regulation #3 as part of an application for a new or modified emissions source releasing any contaminant classified as odorous, hazardous, or toxic.

Air Quality Control Regulation #7 requires that all existing sources that generate volatile organic compounds (VOCs) submit a report to the CDH that provides an inventory of VOC data. RFP submitted the *Volatile Organic Compound (VOC) Emission Report* to CDH in December 1991.

Clean Water Act (CWA)

The National Pollutant Discharge Elimination System (NPDES) permit for RFP expired in 1989 but was extended administratively until renewed. An application was filed with the EPA; an updated renewal application is scheduled to be submitted in mid-1992. No Notices of Violation (NOVs) were received in 1991 for violation of NPDES standards.

An NPDES Federal Facilities Compliance Agreement (FFCA) was signed on March 25, 1991, between the Department of Energy (DOE) and the EPA Region VIII. This agreement involved (1) changes to NPDES monitoring requirements, (2) submittal of three compliance plans: Groundwater Monitoring Plan for the STP Sludge Drying Beds, STP Compliance Plan, and Chromic Acid Incident Plan and Implementation Schedule, and (3) submittal of Quarterly Progress Reports to the EPA that update the status of projects within each plan. A Vadose Zone Monitoring Plan was submitted to EPA and approved in June 1991. The STP Compliance Plan, submitted to EPA in July 1990, includes planned improvements to be implemented in phases during 1992 and 1993. A draft Chromic Acid Incident Plan was submitted to EPA in November 1990; a number of proposed actions have been completed and a final plan was submitted to EPA during March of 1992.

The Spill Prevention Control and Countermeasures/ Best Management Practices Plan (SPCC/BMP) is a compilation of particular requirements for control of hazardous substances and spills. A draft of the SPCC/BMP was generated in October of 1991. A second draft is expected by July 1992 and a final SPCC/BMP by October 1992.

In September 1991, the Colorado Water Quality Control Commission (CWQCC) agreed to hear a petition by DOE to reconsider the classification of Segment 5 (which includes tributaries from source to Ponds A-4, B-5, and C-2) of Big Dry Creek. Segment 5 is currently subject to narrative temporary modifications and goal qualifiers; this indicates that the waters are presently not fully suitable but are intended to become fully suitable for classified use. The CWQCC must take action on these standards before February 1993, or standards now established for Segment 4 (from pond outlets to Standley Lake and Great Western Reservoir) will apply to Segment 5. The hearing is scheduled for October 1992.

The EPA conducted a Compliance Evaluation Inspection on June 21, 1991, to review the findings of the Compliance Sampling Inspection of February 27-28, 1990. No deficiencies were found.

Toxic Substances Control Act (TSCA)

One 55-gallon drum of nonradioactivity-contaminated polychlorinated biphenyl (PCB) waste was shipped off-site for disposal in 1991. Disposal sites for radioactivity-contaminated PCB wastes are unable to receive RFP waste at this time; therefore, RFP is storing 177 drums containing such waste beyond the 1-year storage time limit.

Resource Conservation and Recovery Act (RCRA)

The RCRA Part A permit application for hazardous and low-level mixed waste was revised twice in 1991. Revision 7, requesting a change to interim status to operate certain Non-Destructive Assay (NDA) areas and to correct several EPA waste code listings, was submitted to CDH in June 1991 and is pending CDH approval. Revision 8, which included the new Toxicity Characteristic Leaching Procedure (TCLP) EPA codes and two Size Reduction facilities, was submitted in July 1991 and is also pending CDH approval.

In August 1991, the Part A permit application for hazardous and low-level waste (LLW) and the Part A permit application for TRU mixed waste were submitted to CDH as the Combined Hazardous Waste, Low-Level Mixed Waste, and TRU Mixed Waste, Part A permit application. CDH approved some of the changes requested in this Combined Part A in August 1991; other changes are pending CDH approval. Two other changes to interim status, including requests to super-compact low-level mixed waste and to enhance evaporation at the solar ponds, were requested in a letter during 1991.

The Part B Operating Permit for 9 of 20 hazardous and low-level mixed waste storage units was issued by CDH in September 1991 and became effective in October 1991. In 1989, CDH issued a Notice of Intent to Deny (NOID) for the remaining 11 storage units. RFP submitted a revised Part B permit application in March 1990; this additional information is under review by CDH, as is the Part B permit application for TRU mixed waste.

The Inter-Agency Agreement (IAG) requires RCRA Facility Investigations/Remedial Investigations (RFI/RI) work plans to characterize the source of contamination and the soils of an interim status closure unit. Draft Phase I RFI/RI work plans were submitted to CDH and EPA for the Solar Evaporation Ponds (OU 4), Present Landfill (OU 7), Original Process Waste Lines (OU 9), and West Spray Field (OU 11) in 1990, and for Other Outside Closures (OU 10) in 1991. The 1990 RCRA Annual Groundwater Monitoring Report for OUs was submitted to CDH and EPA on March 1, 1991. The 1991 RCRA report was submitted on March 1, 1992. The CWQCC held hearings to determine whether the RFP groundwater should be subject to site-specific standards and classifications; promulgation of standards and classifications occurred on March 15, 1991, and became effective on April 30, 1991.

In 1991 RFP filed 35 RCRA Contingency Plan Implementation Reports with the CDH. These reports described the nature and magnitude of releases, an assessment of actual or potential hazards to human health or the environment, and actions taken to remediate contaminated areas.

In 1991 RFP notified the National Response Center (NRC) of four releases to the environment of a hazardous substance that equaled or exceeded the reportable quantity. All involved small quantities of ethylene glycol/water mixtures that were immediately cleaned up. No notifications were made to the Local Emergency Planning Committee (LEPC) or State Emergency Response Commission (SERC) because exposure was limited to individuals within plant boundaries.

A Waste Minimization Program Plan and Pollution Prevention Awareness Plan was submitted to EPA and CDH on September 10, 1991.

TRU waste production increased slightly from 77 m^3 in 1990 to 79 m^3 in 1991. LLW production declined from 1830 m^3 in 1990 to 1534 m^3 in 1991. Hazardous non-radioactive waste generation decreased from 69 m^3 in 1990 to 53 m^3 in 1991, representing a 23 percent reduction. An oil conservation project was initiated in 1991, as was another project to abate releases of chlorofluorocarbons to the atmosphere from plant refrigeration and air conditioning systems. Garage oil, solvents, and machine coolant were recycled for fuel blending during 1991. In 1991, the amount of paper recycled increased 62 percent over paper recycled in 1990. Actions were initiated in 1991 to reduce water usage by 7.8 million gallons per year and to reduce cafeteria waste disposal in the sanitary landfill.

On November 3, 1989, the DOE, CDH, and EPA signed a Settlement Agreement and Compliance Order on consent No. 89-10-30-01 regarding alleged violations of the RCRA hazardous waste regulations pertaining to proper waste management of residues. RFP submitted a series of documents in compliance with this Order, the last of which was the Mixed Residues Compliance Plan (September 28, 1990). On July 31, 1991, the CDH issued to RFP Compliance Order No. 91-07-31-01, which indicated that the Mixed Residues Compliance Plan was inadequate and therefore violated the November 1989 Order. On August 1, 1991, the CDH filed a complaint in court alleging that the DOE had submitted an inadequate plan in violation of the November 1989 Order and directed the DOE to meet terms of the Order. Compliance Order No. 91-07-31-01 specifies a schedule for removing all backlog mixed residues from RFP by January 1, 1999, and specifies a schedule by which those residues will be brought into compliance with the Colorado Hazardous Waste Regulations. Activities are in progress to meet those requirements and to negotiate a Consent Order for the management of mixed residues.

FFCA-II (an expansion of the original FFCA signed in 1989) was signed on May 10, 1991, by the EPA and DOE. This new agreement, valid for 2 years, provides the mechanism for DOE to achieve compliance with the LDR portion of the RCRA regulations. FFCA-II requires submittal of six reports and plans; one was submitted in September 1991 and the remaining five are scheduled to be completed in 1992.

Inter-Agency Agreement (IAG)

The IAG was renegotiated early in 1990 following receipt of public and agency comments. The final agreement, reached in January 1991, was revised to increase the number and priority of OUs. Section 4, "Environmental Remediation Programs," describes remediation activities accomplished during 1991.

Emergency Planning and Community-Right-Know Act (EPCRA)

In 1991 there were no reportable releases of extremely hazardous substances or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substances that posed a potential impact beyond RFP boundaries; therefore, no reporting was required under Section 304 of SARA.

The RFP submitted the "Tier II Emergency and Hazardous Chemical Inventory Forms" report to emergency planning agencies for the State of Colorado, Jefferson and Boulder counties, and the RFP Fire Department in 1991. This report is required under Section 312 of EPCRA and lists quantities and locations of hazardous chemicals.

The RFP submitted the "Toxic Chemical Release Inventory" (Form Rs) to EPA in 1991 as required under Section 313 of EPCRA. This report contains information on quantities of routine and accidental releases of chemicals, the maximum amount of chemicals stored, and amount of chemicals contained in wastes transferred offsite.

Agreement in Principle (AIP)

An AIP was executed between DOE and CDH in 1989. Part of that agreement required the CDH to conduct the Rocky Flats Toxicological Review and Dose

Reconstruction study. This study progressed during 1991; a draft report was completed in February 1992.

Special Assignment Team

A Special Assignment Team was mobilized in 1989 by DOE to provide an independent evaluation of operations and practices at RFP. The environmental portion of the audit focused on determining whether RFP activities created an imminent threat to the public or environment, whether operations were conducted in accordance with environmental requirements and best management practices, and the status of previously identified environmental concerns. Findings of this evaluation were addressed in 93 action plans that described corrective measures. As of December 1991, 34 action plans were complete, 29 plans were in verification, 28 plans were open, and 2 plans were scheduled for completion.

Settlement Agreement (Church vs. DOE, et al.)

A settlement agreement among DOE, The Dow Chemical Company, Rockwell International, local governments, and private landowners was reached in July 1985, requiring remediation actions to reduce plutonium contamination on areas adjacent to the RFP eastern boundary. Approximately 120 acres of land have been treated by plowing, tilling, and seeding; plutonium levels are now within state limits. Revegetation measures were conducted on plowed areas during 1991.

METEOROLOGICAL MONITORING

Mean wind speeds at RFP in 1991 were 8.7 miles per hour (mph). The maximum wind speed gust was 83.7 mph. Winds, as categorized by Pasquill stability classes, were 46.2 percent neutral, 42.63 percent stable, and 11.15 percent unstable. The mean temperature in 1991 was 49.17 °F and the minimum and maximum temperatures were -5.8 °F and 91.6 °F, respectively. RFP recorded 16.06 inches of precipitation in 1991.

AIR MONITORING

Effluent Air Monitoring

Plutonium and uranium discharges totaled 0.873 microcuries (μCi) (3.23×10^4 becquerels [Bq]) and 1.631 μCi (6.035×10^4 Bq), respectively. Maximum sample concentration for plutonium was 0.0003×10^{-12} microcuries per milliliter (μCi/ml) and for uranium was 0.0005×10^{-12} μCi/ml. Americium discharges totaled 0.150 μCi (0.422×10^4 Bq) and the maximum concentration was 0.0006×10^{-12} μCi/ml. Total amount of tritium discharged was 0.0048 Ci (1.77 x 108 Bq). Maximum tritium concentration was 94×10^{-12} μCi/ml (3.48 Bq/m^3). Total quantity of beryllium discharged from ventilation exhaust systems was 7.086 grams (g) and the maximum concentration was 0.0018 micrograms per cubic meter (μg/m^3). Radionuclide releases did not exceed NESHAP limits based on computer modeling using the AIRDOS/PC computer code.

Nonradioactive Ambient Air Monitoring

The maximum total suspended particulate (TSP) value (24-hour sample) was 82.3 μg/m^3, and the annual geometric mean value was 39.8 μg/m^3. The maximum Particulate Matter-10 (PM-10) value (24-hour sample) was 26.3 μg/m^3, and the annual arithmetic mean was 13.6 μg/m^3. The annual geometric mean for TSP and arithmetic mean for PM-10 samplers were 66.3 percent and 27.3 percent, respectively, of the National Ambient Air Quality Standards (NAAQS).

Radioactive Ambient Air Monitoring

Overall mean plutonium concentration measured for onsite samplers was 0.073×10^{-15} μCi/ml (2.7×10^{-6} Bq/m^3), equal to 0.36 percent of the Derived Concentration Guide (DCG). Overall mean plutonium concentrations for perimeter and community locations were 0.001×10^{-15} μCi/ml (3.7×10^{-8} Bq/m^3) and 0.001×10^{-15} μCi/ml (3.7×10^{-8} Bq/m^3), respectively. These values were both 0.005 percent of the offsite DCG.

SURFACE-WATER MONITORING

Rocky Flats Plant Site Surface-Water Monitoring

Maximum volume-weighted average concentrations and percent of DCG for plutonium, uranium, americium, and tritium of sampled effluents from North and South Walnut Creeks and Woman Creek are listed below.

	Surface Water Effluents Average Concentrations ($x\ 10^{-9}\ \mu Ci/ml$)	Percent of DCG
Plutonium (Pond C-1)	0.017 ± 0.010	0.06
Uranium-233, 234 (Pond C-2)	0.85 ± 0.09	0.17
Uranium-238 (Pond C-2)	1.00 ± 0.10	0.17
Americium (Pond A-4)	0.010 ± 0.006	0.03
Tritium (Pond C-2)	81 ± 45	0.0

Mean concentrations and percent of DCG for plutonium, uranium, americium, and tritium for samples of raw water taken from Ralston Reservoir and South Boulder Diversion Canal are listed below.

	Raw Water Supply Average Concentrations ($x\ 10^{-9}\ \mu Ci/ml$)	Percent of DCG
Plutonium	0.016 ± 0.034	0.05
Uranium-233, 234	0.44 ± 0.16	0.09
Uranium-238	0.37 ± 0.13	0.06
Americium	0.019 ± 0.021	0.06
Tritium	-19 ± 53	0.00

Community Surface-Water Monitoring

Maximum average reservoir/canal concentrations and percent of DCG for plutonium, uranium, americium, and tritium from samples of public water supplies from several surrounding communities are listed below.

	Maximum Average Reservoir Concentrations ($\times 10^{-9}$ µCi/ml)			Percent of DCG
Plutonium (Standley)	-0.003	±	0.009	-0.01
Uranium-233, 234 (Great Western)	0.52	±	0.14	0.10
Uranium-238 (Standley)	0.57	±	0.12	0.10
Americium (Great Western)	0.005	±	0.007	0.02
Tritium (Dillon)	147	±	182	0.01

Maximum average drinking water concentrations and percent of DCGs for plutonium, uranium, americium, and tritium from samples of drinking water from several surrounding communities are listed below.

	Maximum Average Drinking Water Concentrations ($\times 10^{-9}$ µCi/ml)			Percent of DCG
Plutonium (Golden)	0.011	±	0.017	0.04
Uranium-233, 234 (Thornton)	1.31	±	1.04	0.26
Uranium-238 (Thornton)	1.03	±	0.76	0.17
Americium (Westminster)	0.004	±	0.005	0.01
Tritium (Denver)	104	±	86	0.01

GROUNDWATER MONITORING

The uppermost hydrostratigraphic unit within OU 1 (881 Hillside), which includes alluvial and subcropping bedrock material, is contaminated with VOCs, inorganics (including some metals), and elevated levels of uranium. Organic contaminants detected in the highest concentrations in 1991 were trichloroethene (TCE), 1,1- dichloroethene, and 1,1,1 - trichloroethane (TCA). Concentrations of VOCs diminish rapidly downgradient, becoming equal to or below detection limits (5 µg/l) within 200 feet of the suspected origin of contamination.

Groundwater in the upper hydrostratigraphic unit within OU 2 (903 Pad, Mound, and East Trenches Area), which is composed of alluvial materials and shallow subcropping sandstones, is contaminated with VOCs, inorganics, dissolved metals, and some radionuclides. Contaminants of most concern are VOCs; those detected in 1991 include tetrachloroethene and trichloroethene. Investigations are underway to characterize these plumes and magnitude and extent of contamination.

Dissolved radionuclides detected in surficial wells downgradient and in the immediate vicinity of the Solar Ponds (OU 4) during 1991 include uranium-233, -234 (as high as 1.052×10^{-7} µCi/ml), uranium-235, -238 (7.470×10^{-8} µCi/ml), and tritium. Total radionuclides detected in the uppermost aquifer include americium-241 (1.360×10^{-10} µCi/ml) and in one well, plutonium-239, -240 (3.790×10^{-10} µCi/ml). VOCs detected in surficial wells in the vicinity of the Solar Ponds include trichloroethene, tetrachloroethene, carbon tetrachloride, chloroform, and several others.

Within the confines of the Present Landfill (OU 7), groundwater is contaminated with VOCs, radionuclides, and concentrations of metals and inorganic analytes higher than in upgradient wells. Dissolved radionuclides detected in 1991 in and adjacent to the landfill include tritium (up to 1.834×10^{-6} µCi/ml), strontium-89, -90 (1.117×10^{-8} µCi/ml), uranium-233, -234 (up to 3.22×10^{-8} µCi/ml), uranium-235 (up to 8.0×10^{-10} µCi/ml), uranium-238 (up to 2.05×10^{-8} µCi/ml), and radium-226 (up to 7.7×10^{-10} µCi/ml). Total radionuclides detected include americium-241 (up to 8.0×10^{-11} µCi/ml), cesium-137 (1.06×10^{-9} µCi/ml), and plutonium-239, -240 (up to 1.8×10^{-10} µCi/ml). Radionuclides were detected in a wide area across the landfill site. Detections of VOCs in 1991 occurred primarily in wells in the southern portion of the landfill. A number of different compounds were detected including carbon tetrachloride, trichloroethene, and tetrachloroethene. No VOCs were detected in the uppermost aquifer downgradient of the landfill in 1991.

Within and adjacent to the West Spray Field (OU 11), groundwater quality has been impacted by VOCs, dissolved radionuclides, a few dissolved metals, and inorganic analytes. VOCs detected include TCE, Isobutylmethyl Ketone (MIBK), and toluene at levels just above the detection limit. Dissolved radionuclides detected include uranium-233, -234 (up to 1.62 x 10^{-9} µCi/ml), and uranium-238 (up to 1.15 x 10^{-9} µCi/ml). Total radionuclides in the uppermost aquifer within the West Spray Field included americium-241 (up to 9.6 x 10^{-11} µCi/ml) and plutonium-239 (3.47 x 10^{-10} µCi/ml). Inorganic analytes detected at elevated levels within the West Spray Field include fluoride, chloride, bicarbonate, sodium, sulfate, nitrate/nitrite, orthophosphate, and total suspended solids. Assessments made in 1991 conclude that waste management activities contributed to the presence of these inorganic compounds at OU 11.

SOIL MONITORING

Plutonium concentrations from samples taken at a 1-mile radius from RFP ranged from 0.04 picocuries per gram (pCi/g) to 9.76 pCi/g in 1991. Soils sampled at a 2-mile radius exhibited plutonium concentrations of 0.01 pCi/g to 3.61 pCi/g. Of the soil samples taken, those from the eastern portion of the buffer zone recorded the highest plutonium concentrations: site 1-090, 1.49 pCi/g; site 1-108, 9.76 pCi/g; site 1-126, 2.13 pCi/g; and site 2-090, 3.61 pCi/g.

ECOLOGICAL STUDIES

Baseline Studies, Radioecological Investigations, and Environmental Evaluations occurred as part of the ecological studies programs in 1991. Information gathered on the presence, abundance, and distribution of aquatic and terrestrial vegetation and wildlife is used to measure the impacts of various intrusive activities on these natural resources and comply with the National Environmental Policy Act (NEPA), 40CFR1500-1508, 10CFR1021, and DOE Order 5440.1D, *National Environmental Policy Act Compliance Program.*

ENVIRONMENTAL REMEDIATION (ER) PROGRAMS

Environmental Remediation Programs were established to comply with regulations for characterization and cleanup of inactive waste sites at RFP. DOE, CDH, and the EPA signed the IAG in January 1991, which gives schedules and budgets for ER. The IAG addresses details on specific requirements that must be met during the CERCLA and RCRA processes being employed for assessment and remediation of identified Individual Hazardous Substance Sites (IHSSs) on or adjacent to the RFP. These 178 IHSSs have been categorized into 16 OUs. These OUs, along with activities therein during 1991, are detailed in Section 4, "Environmental Remediation Programs."

EXTERNAL GAMMA RADIATION DOSE MONITORING

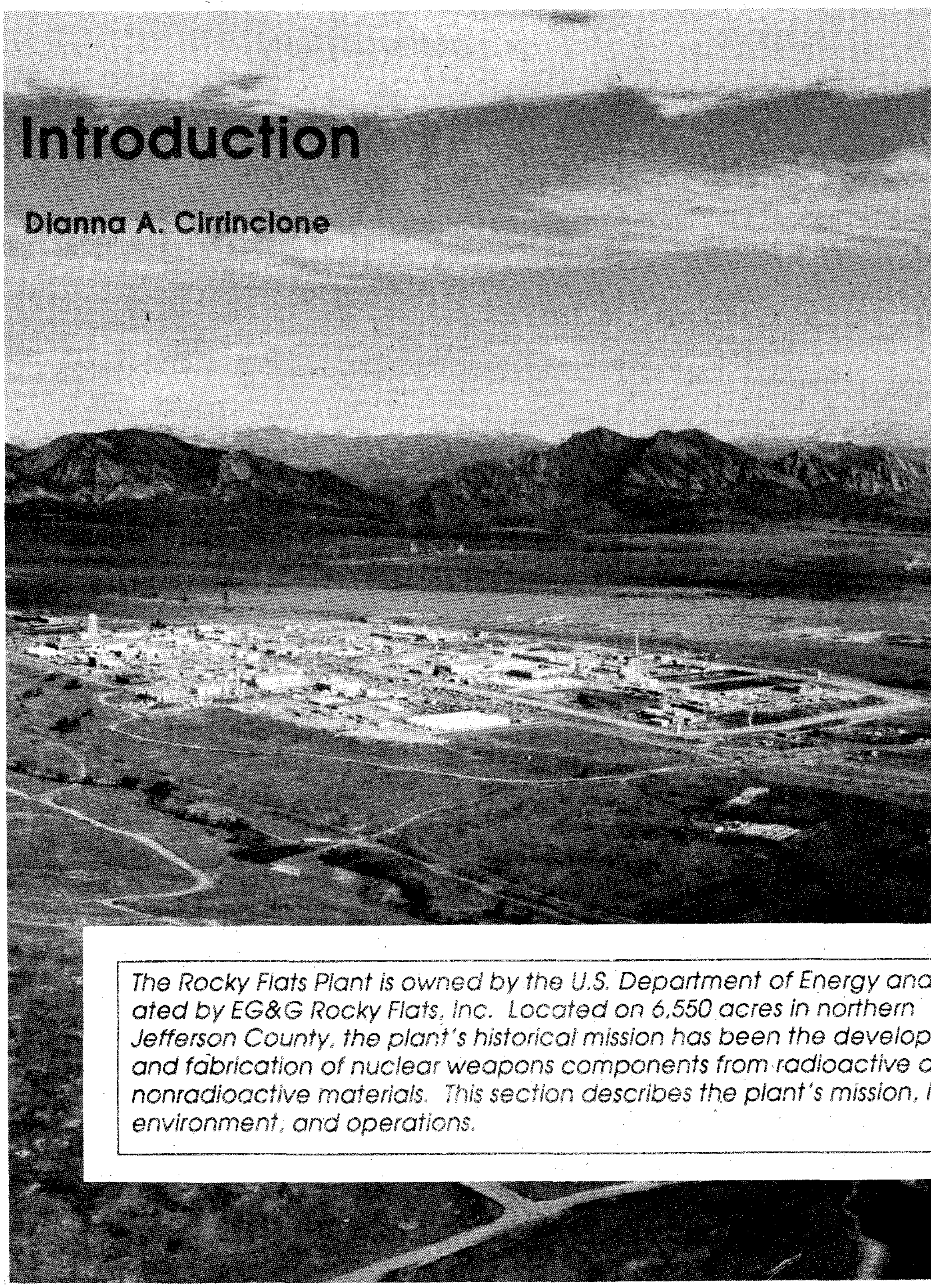
Average annual dose equivalents measured onsite, in perimeter environs, and in nearby communities were 122, 109, and 120 millirem (mrem), respectively. These values are indicative of background gamma radiation in the area.

RADIATION DOSE ASSESSMENT

Maximum radiation dose from all pathways to a hypothetical individual continuously present at the site boundary was 3.2×10^{-1} mrem EDE. The maximum radiation dose to an individual from RFP air emissions of radioactive materials, as determined by the AIRDOS-PC meteorological dispersion/radiation dose computer code, was 4.4×10^{-5} mrem EDE from measured building air emissions and 9.3×10^{-3} mrem EDE from estimated soil resuspension. Collective population dose to a distance of 50 miles was estimated as 0.9 person-rem EDE.

1. Introduction

Dianna A. Cirrincione



The Rocky Flats Plant is owned by the U.S. Department of Energy and operated by EG&G Rocky Flats, Inc. Located on 6,550 acres in northern Jefferson County, the plant's historical mission has been the development and fabrication of nuclear weapons components from radioactive and nonradioactive materials. This section describes the plant's mission, its site environment, and operations.

ROCKY FLATS SITE ENVIRONMENT

The Rocky Flats Plant (RFP) occupies an area of 6,550 acres in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver (Figure 1-1). Main production facilities are located near the center of RFP within a fenced security area of 384 acres. The remaining plant area contains limited support facilities and serves as a buffer zone to major production areas (DOE80). (Note: Literature citations abbreviated within this report are alphabetically listed in Section 8, "References.")

Approximately 2.1 million people live within a 50-mile radius of RFP. Adjacent land use is a mixture of agriculture, open space, industry, and low-density residential housing.

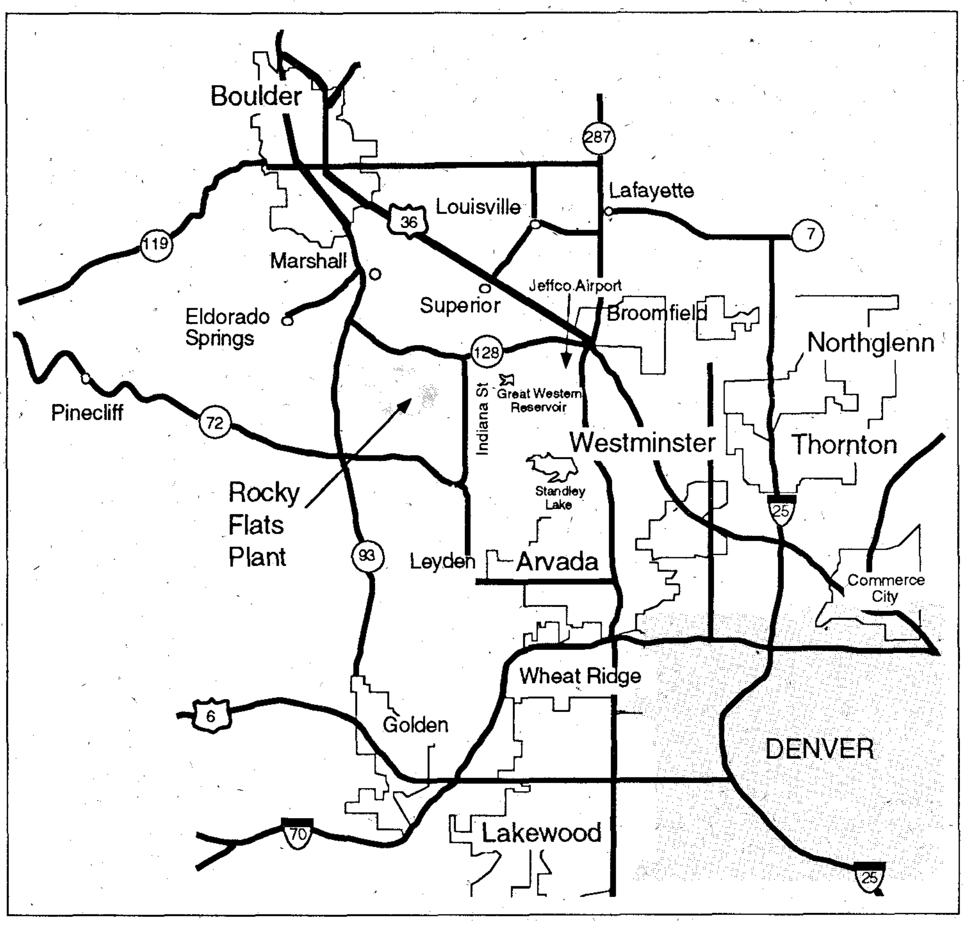


Figure 1-1. Area Map of RFP and Surrounding Communities

Climate

The climate at RFP is characterized by dry, cool winters and warm summers. Elevation and major topographical features significantly influence climate and meteorological dispersion characteristics of the site. Winds, though variable, are predominately northwesterly. Annual precipitation averages slightly greater than 15 inches with more than 80 percent occurring between April and September. Maximum and minimum temperatures average 76 degrees Fahrenheit (°F) and 22 °F, respectively (DOE80). Meteorological and climatological information for 1991 is given in Section 3.1.

Topography

RFP is situated at an elevation of about 6,000 feet on the eastern edge of a geological bench known locally as Rocky Flats. This bench, approximately 5 miles wide in an east-west direction, flanks the eastern edge of the abruptly rising foothills of the Front Range of the Rocky Mountains. To the east, topography slopes gradually at an average downgrade of 95 feet per mile. Approximately 20 miles to the west, the continental divide rises to elevations exceeding 14,000 feet.

Geology

RFP is situated on the Rocky Flats Alluvium, an alluvial fan deposit, varying in thickness from 0 to 100 feet, providing a gravelly cover over bedrock. Underlying bedrock formations consist primarily of claystone with some siltstones. Seismic activity of the area is low, and potentials for landslides and subsidence are not considered likely at RFP (DOE80). Additional information on the geology of RFP is contained in *Geologic Characterization of the Rocky Flats Plant* (EG911).

Hydrology

Surface drainage generally occurs in a west to east pattern along five ephemeral streams within RFP. North Walnut Creek, South Walnut Creek, and Woman Creek drain the main plant facilities area. Water from Woman Creek drains into Standley Lake, which is used as a municipal water supply. Surface runoff from RFP is collected in an interceptor ditch before it enters Woman Creek, diverted to a temporary holding pond, and piped into the Broomfield Diversion Ditch, bypassing Great Western Reservoir. Water from North and South Walnut Creek discharges into the Broomfield Diversion Ditch.

Groundwater systems consist of a shallow, unconfined system in the Rocky Flats Alluvium and a confined system in deeper sandstone units within the underlying bedrock. The flow of groundwater is locally controlled by the topography and subcropping sandstone channels (refer to Figure 3.4-1, Generalized Cross Section of the Stratigraphy Underlying the RFP).

ROCKY FLATS SITE OPERATIONS

Construction of RFP was approved by the United States Government in 1951. The purpose of the facility was to increase production of nuclear weapons components. Limited operations began in 1952 within a total site area of 2,520 acres and a plant facilities area of less than 400 acres. Early operations involved 700,000 square feet (ft^2) of building floor space in 20 structures.

The United States Atomic Energy Commission (AEC) was the responsible government agency when construction began at RFP. In 1974, the United States Energy Research and Development Administration (ERDA) succeeded the AEC. The ERDA was in turn succeeded by the DOE in 1977. Within DOE, administrative responsibility was delegated to the Albuquerque Operations Office, which established the Rocky Flats Area Office for day-to-day contact at RFP. In 1989, the Rocky Flats Area Office was upgraded to the Rocky Flats Office (RFO), accountable directly to DOE Headquarters (HQ) in Washington, D.C.

The Dow Chemical Company was the first prime contractor for operations at RFP. Rockwell International replaced The Dow Chemical Company in 1975 and operated RFP through 1989. EG&G Rocky Flats, Inc., replaced Rockwell International in 1990.

The RFP fabricates nuclear weapons components from plutonium, uranium, beryllium, and stainless steel.

Production activities include metal fabrication and assembly, chemical recovery and purification of process-produced transuranic radionuclides, and related quality control functions. Approximately 140 structures contain nearly 2.76 million ft^2 of floor space. Of this space, major manufacturing, chemical processing, plutonium recovery, and waste treatment facilities occupy approximately 1.6 million ft^2. EG&G Rocky Flats, Inc., employed 7,068 people in December 1991.

RADIATION AT THE ROCKY FLATS PLANT

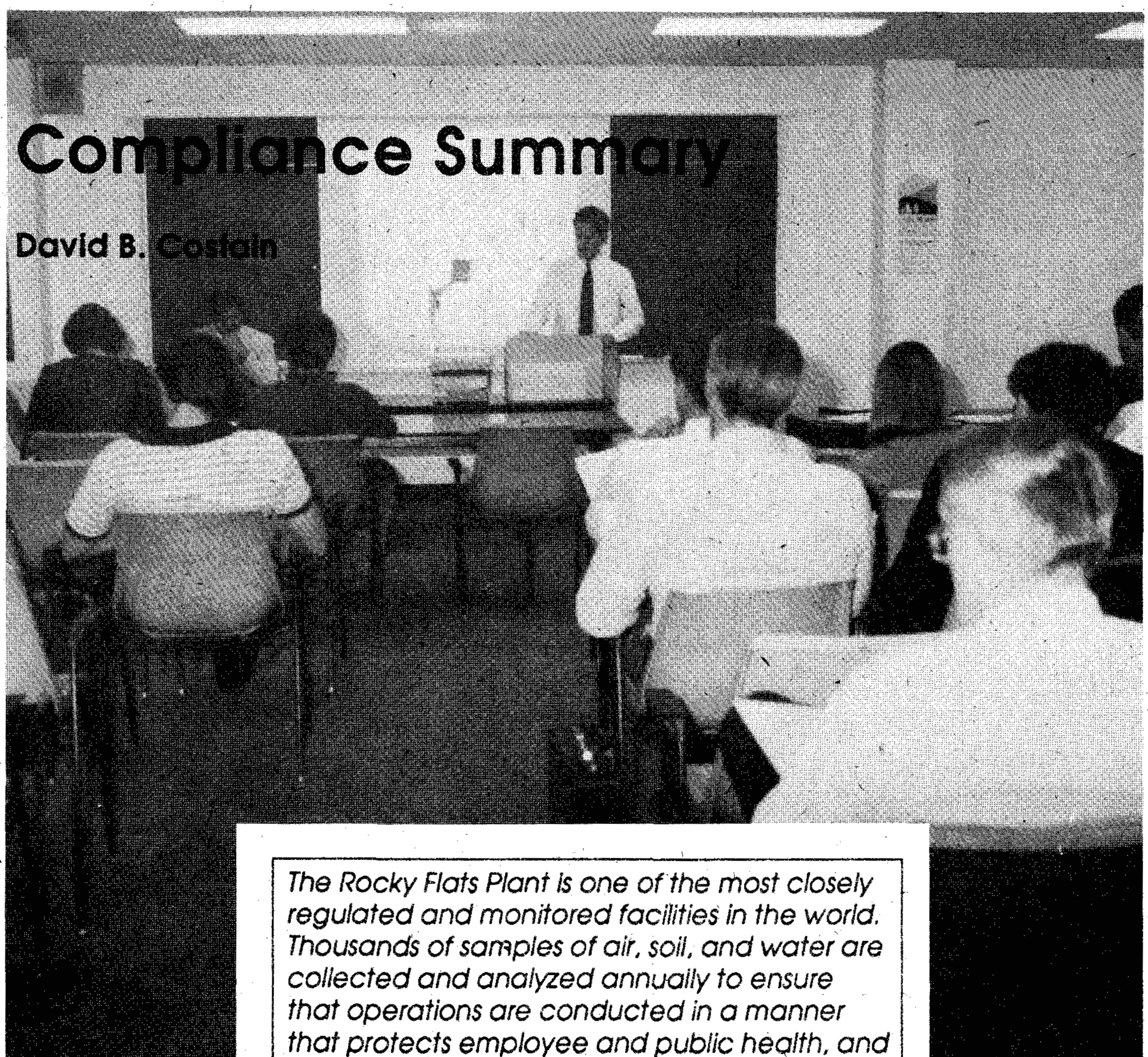
The RFP uses radioactive materials and radiation-producing equipment. Radiation-producing equipment includes X-ray machines and linear accelerators. Important radioactive materials include plutonium, americium, uranium, and tritium. The potential exists for these materials to be handled in sufficient quantities to pose an offsite hazard. The most important potential contributor to radiation dose from these materials is the alpha radiation emitted by plutonium, americium, and uranium.

Because of the low penetrating ability of alpha radiation, these materials are primarily a potential internal radiation dose hazard; that is, the radioactive material must be taken into the body for the alpha radiation to be harmful. For this reason, environmental protection at RFP focuses on minimizing release of radioactive materials to the environment. Environmental monitoring focuses on pathways by which the materials could enter the body, such as air inhalation and water ingestion. A pathway is a potential route for exposure to radioactive or hazardous materials.

Appendix A, "Perspective on Radiation," describes the basic concepts of radiation. Readers unfamiliar with the types and sources of ionizing radiation are encouraged to read Appendix A for a better understanding of environmental monitoring data and radiation dose assessment at RFP. A detailed assessment of radiation dose to the public from RFP is presented in Section 6, "Radiation Dose Assessment."

2. Compliance Summary

David B. Costain



The Rocky Flats Plant is one of the most closely regulated and monitored facilities in the world. Thousands of samples of air, soil, and water are collected and analyzed annually to ensure that operations are conducted in a manner that protects employee and public health, and the environment. The results of these analyses are reported during monthly public meetings (pictured), as well as to various local, state, and federal regulatory authorities. The Compliance Summary provides a description of environmental regulations and requirements that govern Rocky Flats Plant activities.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

NEPA is the nation's most widely applied federal environmental statute. Federal regulations administered by the Council on Environmental Quality (CEQ), Washington, D.C., require NEPA documentation as an administrative record showing that agencies have considered environmental impacts of and public commentary on proposed actions, and that this information is included in federal decision-making. NEPA documentation can include either an Environmental Assessment (EA) or an Environmental Impact Statement (EIS).

In 1989 Admiral Watkins, Secretary of Energy, issued a ten-point initiative that renewed emphasis by DOE on the letter and spirit of environmental statutes and regulations. Secretary of Energy Notice SEN-15-90 was the fourth point in the initiative, becoming effective on February 5, 1990. The notice called for a revision of DOE Order 5440.1C, *National Environmental Policy Act*, by streamlining and centralizing the DOE line organizations. The responsibilities of the DOE Secretarial Officers were redefined, and in states where DOE facilities are located, the State Governors are now able to work more closely with their local DOE representatives.

The RFP established a NEPA Compliance Committee (NCC) in February 1989 to provide an integrated review, guidance, and oversight for plantwide activities. The NCC created an RFP Environmental Checklist (EC) that is required for all proposed actions. The EC provides an initial screening and review of construction and engineering projects to determine whether submission of an Action Description Memorandum (ADM) is required. ADMs are submitted to DOE for a determination of the level of NEPA documentation required.

In 1991 the NCC at RFP provided information and recommendations on approximately 150 projects concerned with constructing, refurbishing, or upgrading RFP facilities.

Notice of Intent (NOI)

The NOI is a public announcement by a federal agency of plans to prepare an EIS. This announcement is followed by public meetings where suggestions are received on the scope and range of the EIS.

The NOI for the Plutonium Recovery Modification Project Environmental Impact Statement (PRMP EIS) was published in the *Federal Register* on May 30, 1990. Public scoping meetings were held on June 18 and 20, 1990, followed by a 45-day comment period. A draft Implementation Plan for the PRMP EIS was completed in November 1991.

The NOI for the Programmatic Environmental Impact Statement (PEIS) on the Integrated Environmental and Waste Management Program, proposed by the DOE, was issued in the *Federal Register* on October 22, 1990. A public scoping meeting to accept comments on the PEIS was held on January 23, 1991. An Implementation Plan is under development. The PEIS will consider programmatic issues (for all DOE-operated facilities) and integrated approaches to the program and will include national program-wide alternatives.

In September 1990, the Secretary of Energy made a commitment to initiate preparation of the RFP Sitewide EIS. The NOI for the Sitewide EIS was published in the *Federal Register* on March 13, 1991. Public scoping meetings were held on April 4, 8, and 11, 1991, and comments were accepted through April 19, 1991.

Environmental Assessment (EA)

An EA is prepared to determine whether a proposed federal action will require preparation of an EIS. If it is determined that no EIS is required, a Finding of No Significant Impact (FONSI) that documents this decision is prepared. Before preparation of an EA, the proposed federal action is evaluated as a possible Categorical Exclusion (CX). The CX is a category of actions that do not individually or cumulatively have a significant effect on the human environment and do not require either an EA or EIS. Eleven CXs were approved for RFP in 1991.

EAs for the following proposed actions are in various stages of preparation and review.

- Building 374 Liquid Waste Treatment Facility Upgrades
- Construction and Use of a Residue Drum Storage Facility
- Mixed Waste Disposal Operations at the Nevada Test Site
- New Sanitary Landfill
- Proposed Subsurface Interim Measures/Interim Remedial Action Plan/Environmental Assessment and Decision Document for OU 2

The EA for the Interim Remedial Action/ Environmental Assessment for Operable Unit 2 (OU 2) (903 Pad, Mound, and East Trenches areas) was prepared. A FONSI for this proposed action was received on March 7, 1991.

Preparation of an EA for the Dewatering and Resource Conservation and Recovery Act (RCRA) Partial Closure Action on Solar Evaporation Ponds began in 1990. The EA was approved on February 21, 1991, and a FONSI was received on June 17, 1991. A Notice of Availability was published on August 9, 1991.

Mitigation Action Plan (MAP)

The implementation of NEPA focuses on the predecisional aspects of an action. Mitigation is part of the postdecisional phase of NEPA. The Secretary of Energy Notice SEN-15-90, Section H, requires the publication of a MAP before an EIS or EA/FONSI is completed. The MAP documents environmental commitments made in an EIS/Record of Decision (ROD) or an EA/FONSI and reports implementation of those commitments.

An EA for the Supercompactor and Repackaging Facility (SARF), DOE/EA-0432, was published in July 1990; the DOE issued a FONSI in the *Federal Register* on August 10, 1990. The MAP for the SARF was approved in January 1992.

ENDANGERED SPECIES ACT, FISH AND WILDLIFE COORDINATION ACT, MIGRATORY BIRD TREATY ACT, AND EXECUTIVE ORDERS 11990 (PROTECTION OF WETLANDS) AND 11988 (FLOODPLAIN MANAGEMENT)

These federal statutes and executive orders govern the protection of ecological resources at RFP. In 1991 a Public Notice of Wetland Involvement was published in the *Federal Register* as required by 10CFR1022. This notice, made on August 23, 1991, concerned the placement of sediment samplers in the buffer zone surrounding the main facilities area. Biological survey and habitat survey reports were prepared for the South Interceptor Ditch (DOE91a, DOE91b) and 881 Hillside French Drain (DOE91c, DOE91d) in October and November 1991, respectively.

NATIONAL HISTORIC PRESERVATION ACT (NHPA)

Preservation and management of prehistorical, historical, and cultural resources on lands administered by the DOE are mandated under Sections 106 and 110 of NHPA. The NHPA requires a federal agency, before undertaking any project, to adopt measures to mitigate the potential adverse effects of that project on sites, structures, or objects eligible for inclusion in the National Register of Historic Places.

A sitewide archaeological survey of RFP was conducted in 1991. All cultural resources were evaluated against criteria for nomination to the National Register of Historic Places. Results of the survey were reported in "Cultural Resources Class III Survey of Department of Energy, Rocky Flats Plant, Northern Jefferson and Boulder Counties, Colorado" (Version 1.0, August 1, 1991). Information from this report is used in planning remediation and other construction activities to prevent damage to, or destruction of, cultural resources at RFP.

FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)

FIFRA governs the registration and use of pesticides, herbicides, and rodenticides. At RFP, compliance with FIFRA is managed through the Integrated Pest Management Control Plan. This plan identifies the kinds of activities at RFP that are subject to FIFRA and describes the procedures for complying with FIFRA requirements.

The Integrated Pest Management Control Plan is part of the Watershed Management Plan, which is in draft form because certain sections are being rewritten.

However, the Integrated Pest Management Control Plan is complete and currently functional.

CLEAN AIR ACT (CAA)

The CAA sets standards for ambient air quality and hazardous air pollutants. At RFP, compliance programs have been established for radioactive and nonradioactive hazardous emissions and ambient air conditions.

National Emission Standards for Hazardous Pollutants (NESHAPs)

NESHAPs govern both radioactive and nonradioactive pollutants and are administered by the EPA or the CDH. CDH has been granted authority by the EPA to regulate several hazardous pollutants including beryllium, mercury, vinyl chloride, and asbestos; however, authority to regulate radionuclides currently lies with the EPA. Under regulations promulgated in 1989, NESHAPs limited the radiation dose from airborne radionuclide emissions from DOE facilities to 10 millirems per year (mrem/yr) effective dose equivalent (EDE) to any member of the public. A compliance report with dose calculations is due to EPA by June 30 of each year for the previous calendar year. RFP submitted the required Air Compliance Report and dose calculations for the calendar year 1990 to the EPA in June 1991. This report showed a calculated whole body dose equivalent to the maximally exposed individual from building air emissions of 0.000043 mrem and from soil resuspension of 0.21 mrem. Dose calculations for the 1991 calendar year are given in Section 6, "Radiation Dose Assessment."

Colorado Air Quality Control Regulation No. 8

Regulation No. 8 implements NESHAPs for nonradioactive hazardous air pollutants in Colorado. Work standards, emission limitations, and ambient air standards for hazardous air pollutants including asbestos, beryllium, mercury, benzene, vinyl chloride, lead, and hydrogen sulfide are specified in this regulation. Potential hazardous air pollutants at RFP include asbestos and beryllium. Asbestos was used as insulation in the older facilities and is handled according to NESHAPs regulations during demolition, renovation, or disposal. Beryllium is machined at RFP. The emissions standard is 10 grams (g) of beryllium over a 24-hour period. Beryllium emissions did not exceed this standard in 1991 (see Section 3.2, "Air Monitoring").

Beryllium compliance tests were to be conducted on five air effluent ducts that have the highest potential beryllium emissions in 1991 upon resumption of plutonium operations at RFP. The tests were to measure beryllium emissions from each of the five locations over a 24-hour period in accordance with EPA Reference Method 104 and serve as the basis of an application for a waiver of emission testing and sampling protocol. Plutonium process operations were suspended in 1989 and did not resume in 1990 or 1991. Anticipated changes in future plant operations may curtail beryllium operations at RFP and render compliance testing unnecessary.

Colorado Air Quality Regulation No. 3

The State of Colorado has primacy for regulating nonradionuclide air pollutant emissions as defined under the CAA. As a result, enforcement, maintenance, and implementation of the air regulations have been delegated by the State to the CDH. Under the provisions of Colorado Air Quality Regulation No. 3, the CDH must receive an Air Pollutant Emission Notice (APEN) for all potential sources of air pollutants resulting from construction or alteration of any facility, process, or activity from which air pollutants are to be emitted. The air pollutants are defined as criteria, hazardous, or toxic. APENs are required for any process or activity that has the potential of (1) an uncontrolled emission greater than 1 pound per day for any hazardous or toxic air pollutant, (2) an uncontrolled emission greater than 1 ton per year for any criteria, hazardous, or toxic air pollutant, or (3) emissions arising from specific operations as defined in Regulation No. 7. Each APEN must be filed with the CDH before initiation of operations.

Air emission permits are required for sources that have the potential for significant impact on air quality unless specifically exempt by law. Table 2-1 lists current air quality permits for RFP as well as surface water and hazardous waste permits and permit applications.

Under the June 1989 Agreement in Principle (AIP) between the DOE and the CDH, RFP was required to complete an air emission inventory of plant operations and submit inventory data to the CDH by June 1991. Between June 1989 and June 1991, RFP conducted an air emission survey of plant activities, evaluated process operations, and prepared APENs and supporting documentation for submittal to the CDH. The buildings and operations for which APEN documents were submitted in 1991 are listed in Table 2-2.

Colorado Air Quality Control Regulation No. 7

Under provisions of Regulation No. 7, all existing sources that generate volatile organic compounds (VOCs) are required to submit to the CDH a report that provides an inventory of all VOC point sources, operation source descriptions, actual and potential annual emissions, and discussions of reasonable available control technology (RACT). In response to this requirement, RFP submitted the *Volatile Organic Compound (VOC) Emissions Report* (EG91m) to CDH in December 1991. The basis of this report was the RFP air emission inventory documentation that provided VOC point-source information.

Compliance Issues

Radioactive Effluent Sampling Protocol. Several studies were initiated in 1990 to determine RFP's compliance with EPA's radioactive effluent sampling protocol, described under 40CFR61, Subpart H, which was promulgated on December 15, 1989, and made effective that same date. These studies involve preparing "as-built" duct drawings, duct effluent velocity profiling, effluent particle size and composition, and isokinetic sampling. The "as-built" duct drawing study was completed in 1991. The other projects will be completed in 1992-1993. RFP is pursuing upgrades to those sampling systems that do not comply with the intent of the EPA effluent sampling protocol. Effluent monitoring systems that do not meet EPA protocol, but meet the intent of the regulations, will be reviewed for exemption under "alternative methods," provisions of 40CFR61.93(b)(3). Attempts in 1991 to enter into a Federal Facilities Compliance Agreement (FFCA) with EPA Region VIII to establish a schedule for achieving compliance were unsuccessful when it was determined by EPA that such an agreement would be inappropriate. EPA issued a Section 114 (CAA) letter on November 27, 1991, requesting information on RFP compliance with NESHAP provisions. Responses were submitted by RFP on December 16, 1991, and January 27, 1992. EPA Region VIII issued EG&G Rocky Flats, Inc., a Compliance Order on March 3, 1992, requiring RFP to be in compliance with the effluent monitoring requirements of 40CFR61.93(b) within 1 year and to complete four specified projects within 270 days.

CLEAN WATER ACT (CWA)

The CWA requires the EPA to set national effluent limitations and water quality standards and establishes a regulatory program to ensure enforcement. In Colorado, discharge permits for federal facilities such as RFP are issued by the EPA. The State of Colorado sets water quality standards for receiving streams and bodies of water. These standards are applied through National Pollutant Discharge Elimination System (NPDES) permits issued for RFP by the EPA. Table 2-1 lists the current NPDES permit for RFP.

National Pollutant Discharge Elimination System (NPDES) Permit

The NPDES permit program controls the release of pollutants into U.S. waters and requires routine monitoring and reporting of results. The NPDES permit for RFP (#CO-0001333) identifies seven monitoring points for control of discharge; three of these discharge points, Ponds A-4, B-5, and C-2, are capable of discharging water offsite. The NPDES permit terms were modified by the NPDES FFCA to eliminate two discharge points that were inactivated (the Reverse Osmosis Pilot Plant and the Reverse Osmosis Plant) and to include new monitoring parameters at the other discharge locations. Changes to the NPDES permit terms are summarized in Appendix B (Table B-4) and went into effect in April 1991. The current permit expired in 1989 but was administratively extended until renewed. An application for renewal was filed with EPA, and an updated renewal application (which will include the application for a storm water discharge permit) is scheduled to be submitted in mid-1992. No Notices of Violation

(NOVs) were received in 1991 for violation of NPDES requirements. NPDES permit exceedances are summarized in Section 3.3, "Surface Water Monitoring."

Table 2-1
Environmental Permits and Permit Applications

Permit/ Application	Number	Medium	Issuing Agency	Status
NPDES (12/26/84)	CO-0001333	Water	EPA	Application for revision pending
Building 122 Incinerator (3/25/82)	C-12,931	Air	CDH	Active permit (inactive source)
Building 771 Incinerator (8/28/85)	12JE932	Air	CDH	Active permit (inactive source)
Building 776 Incinerator (3/25/82)	C-13,022	Air	CDH	Active permit (inactive source)
Fugitive Dust Renewed (12/28/89)	87JE084L	Air	CDH	Active permit
Pondcrete Shelter #5 Pad #750	90JE045-1	Air	CDH	Initial approval
Pondcrete Shelter #6 Pad #750	90JE045-2	Air	CDH	Initial approval
Pondcrete Shelter #10 Pad #904	90JE045-3	Air	CDH	Initial approval
Pondcrete Shelter #11 Pad #904	90JE045-4	Air	CDH	Initial approval
Urinalysis Laboratory Fume Hood Bldg. 123	86JE018	Air	CDH	Active permit
Building 776 Supercompactor and Repackaging Facility (SARF)/transuranic Waste Shredder-HEPA filter	91JE047	Air	CDH	Initial permit issued in December 1991
Building 333 paint spray booth and grit blaster	91JE300	Air	CDH	Initial permit to be issued when permit fees are paid
Building 910 three forced evaporation units and two natural gas fired heaters	91JE316	Air	CDH	Initial permit will be issued when permit fees are paid
Building 995 sanitary waste water treatment plant belt filter press and indirect natural gas fired sludge dryer	91JE430	Air	CDH	Initial permit will be issued when permit fees are paid
Building 440 paint spray booth	91JE537-1	Air	CDH	Initial permit issued in November 1991
Building 440 paint spray booth	91JE537-2	Air	CDH	Initial permit issued in November 1991
RCRA Part A	CO-7890010526 for Revisions	Hazardous, low-level mixed waste, transuranic mixed waste plus mixed residues	CDH	Part A applications for hazardous and low-level mixed waste and transuranic mixed wastes and residues are combined

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Pondcrete Shelter #6 Pad #750	90JE045-2	Air	CDH	Initial approval
Pondcrete Shelter #10 Pad #904	90JE045-3	Air	CDH	Initial approval
Pondcrete Shelter #11 Pad #904	90JE045-4	Air	CDH	Initial approval
Urinalysis Laboratory Fume Hood Bldg. 123	86JE018	Air	CDH	Active permit
Building 776 Supercompactor and Repackaging Facility (SARF)/transuranic Waste Shredder-HEPA filter	91JE047	Air	CDH	Initial permit issued in December 1991
Building 333 paint spray booth and grit blaster	91JE300	Air	CDH	Initial permit to be issued when permit fees are paid
Building 910 three forced evaporation units and two natural gas fired heaters	91JE316	Air	CDH	Initial permit will be issued when permit fees are paid
Building 995 sanitary waste water treatment plant belt filter press and indirect natural gas fired sludge dryer	91JE430	Air	CDH	Initial permit will be issued when permit fees are paid
Building 440 paint spray booth	91JE537-1	Air	CDH	Initial permit issued in November 1991
Building 440 paint spray booth	91JE537-2	Air	CDH	Initial permit issued in November 1991
RCRA Part A	CO-7890010526 for Revisions	Hazardous, low-level mixed waste, transuranic mixed waste plus mixed residues	CDH	Part A applications for hazardous and low-level mixed waste and transuranic mixed wastes and residues are combined

Table 2-2 (continued)
Buildings for Which Air Pollutant Emission Notices Were Submitted in 1991

Building Reference Number(s)	Building/Operation Description	Date Submitted To CDH
885	Paint & Oil Storage	03/29/91
714	Hydrogen Fluoride Storage Building	03/29/91
714A	Hydrogen Fluoride Storage Shed	03/29/91
865	Material & Process Development Lab.	03/29/91
867	Filter Plenum (865)	03/29/91
868	Filter Plenum (865)	03/29/91
879	Filter Plenum (883)	03/29/91
883	Rolling & Forming Facility	03/29/91
374	Process Waste Treatment Facility	04/03/91
910	Solar Pond - Evaporation Project	04/03/91
207A-C	Solar Pond	04/03/91
449	Oil & Paint Storage	04/26/91
T371J	Subcontractor Radiography Trailer	04/27/91
875	Filter Plenum Building (886)	04/30/91
886	Nuclear Safety Facility	04/30/91
886A	Trailer	04/30/91
T690J	Trailer - Laboratory	04/30/91
T690K	Trailer - Laboratory	04/30/91
T690L	Trailer - Laboratory	04/30/91
T690A	Trailer	04/30/91
453	Oil Storage	05/13/91
460	Nonnuclear Manufacturing	05/13/91
701	Maintenance Building	05/13/91
780	Flammable Storage	05/13/91
866	Process Waste Transfer Building	05/13/91
990	Sanitary Wastewater Treatment	05/13/91
990A	Sanitary Wastewater Treatment	05/13/91
995	Sewage Treatment Facility	05/13/91
988	Storage Vault	05/13/91
228A	Drying Beds (910)	05/13/91
228B	Drying Beds (910)	05/13/91
566	Protective Clothing Decontamination	05/16/91
556	Metal Cutting Building	05/20/91
772	Fluorine Storage Building	05/20/91
965	Storage Building	05/20/91
331	Garage & Fire Station	05/30/91
334	General Shop (Maintenance)	05/30/91
439	Mod Center/Machine Shop	05/30/91
788	Cementation Process Building	05/30/91
881	Research & General Support	05/30/91
889	Waste Packaging/Decontamination	05/30/91
985	Filter Plenum Building (996, 997, 999)	05/30/91
991	Product Warehouse	06/27/91
440	Modification Center	06/28/91
778	Service Building	06/28/91
980	Subcontractor Metal Shop	06/28/91
124	Water Treatment Plant	07/17/91
129	Raw Water Strainer	07/17/91
RFP - Sitewide	Natural Gas Combustion Units	07/17/91
111	Administration	07/31/91
708	Compressor Building	08/07/91
709	Cooling Tower (707)	08/07/91
711	Cooling Tower (707)	08/07/91

Table 2-2 (continued)

Buildings for Which Air Pollutant Emission Notices Were Submitted in 1991

Building Reference Number(s)	Building/Operation Description	Date Submitted To CDH
120	Emergency Generator	08/07/91
124	Emergency Generator	08/07/91
372A	Emergency Generator	08/07/91
662	Emergency Generator	08/07/91
708	Emergency Generator	08/07/91
729	Emergency Generator	08/07/91
762A	Emergency Generator	08/07/91
779	Emergency Generator	08/07/91
792A	Emergency Generator	08/07/91
920	Emergency Generator	08/07/91
122	Medical	10/11/91
122S	Storage Shed	10/11/91
123 (Revision 1)	Health Physics	10/16/91
123S (Revision 1)	Hazardous Waste Storage Shed Hot Water Heaters	10/16/91
207A-C (Revision 1)	Solar Pond Project	12/09/91

The AIP established a procedure whereby RFP would provide CDH with split samples of water proposed for discharge from the terminal ponds. This allows CDH to assess water quality before a discharge. Samples are split for analysis by CDH, EG&G Rocky Flats, Inc., and independent EPA-registered laboratories. Presently, once CDH has made its assessment and given concurrence for discharge, pond waters are discharged directly to the Broomfield Diversion Ditch.

The NPDES permit requires the maintenance of terminal pond water levels at 90 percent of capacity to allow sufficient storage volume for spill containment. However, because of inherent delays caused by concurrent sampling and analysis (before receiving CDH concurrence for discharges) and continuing storage of inflows, Ponds A-4, B-5, and C-2 have operated with less than 90 percent spill capacity.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, specifies radionuclide concentration guides for water discharged from RFP as follows: "Implementation of the Best Available Technology (BAT) process for liquid radioactive wastes are not required where radionuclides are already at low levels, i.e., the annual average concentration is less than the

Derived Concentration Guide (DCG) level. In that case, the cost consideration component of BAT analysis precludes the need for additional treatment, since any additional treatment would be unjustifiable on a cost-benefit basis." Impounded waters at RFP met these DCG standards; therefore, per DOE Order 5400.5, further treatment was unjustified on a cost-benefit basis. Nevertheless, because of CDH guidance, RFP used activated carbon treatment systems for organics removal and filtration to remove particulates, to process approximately 118 million gallons discharged before October 1991 as an added level of protection. Treatment was not used for discharges after October 1991 per concurrence with CDH. Approximately 45 million gallons were discharged from October through December 1991.

NPDES Federal Facilities Compliance Agreement (FFCA). The NPDES FFCA was signed on March 25, 1991, between DOE and EPA Region VIII. The FFCA incorporated changes to NPDES monitoring requirements. These changes included relocating the point of compliance for outfall 001 from Pond B-3 to the Sewage Treatment Plant (STP) discharge for most parameters. Monitoring requirements for total chromium and Whole Effluent Toxicity (WET) at the terminal ponds, and for metals, VOCs, and WET at the STP discharge site were also added.

The FFCA also required submittal of three compliance plans that address planned administrative and physical changes to the plant: the Groundwater Monitoring Plan for the STP Sludge Drying Beds, the STP Compliance Plan, and the Chromic Acid Incident Plan and Implementation Schedule. The FFCA also requires submittal of Quarterly Progress Reports to the EPA that update the status and schedule of projects within each compliance plan.

(1) Groundwater Monitoring Plan for the STP Sludge Drying Beds. A draft Groundwater Monitoring Plan was submitted to EPA in July 1990. The plan proposed a method for characterizing groundwater beneath the sludge drying beds located east of the STP. The EPA subsequently recommended a phased approach beginning with monitoring and characterization of soil and water in the vadose zone. The Vadose Zone Monitoring Plan was submitted to EPA and approved in June 1991. An addendum to the monitoring plan was submitted for two additional sludge drying beds located east of Building 910. Field work at both locations will be initiated during 1992.

(2) STP Compliance Plan. The STP Compliance Plan was submitted to EPA in July 1990. This plan described planned improvements to the STP necessary to meet NPDES water quality standards and FFCA criteria. Completed work includes implementation of recommendations from diagnostic studies of treatment plant operations, installation of an autochlorination/dechlorination system, and additional influent and effluent instrumentation. Other planned improvements are included in a treatment plant upgrade project, which consists of three phases.

- Phase I includes construction of a mechanical sludge drying system and modifications to existing sludge beds to improve the efficiency of the sludge drying process. Construction is expected to be completed during 1992.

- Phase II includes electrical improvements for improved reliability and additional capacity, emergency electrical power provisions, construction of an addition to the existing laboratory building, addition of equipment and controls at the equalization basins, upgrades to existing structures and equipment within the STP including the polymer feed system and sand filters, and additional chemical storage. Construction is expected to begin during 1993.

- Phase III includes construction of additional influent and effluent storage for the STP, modification of the existing plant to provide for nitrification, and construction of a new denitrification system. The final scope of Phase III is being refined through continuing negotiations with EPA.

(3) Chromic Acid Incident Plan and Implementation Schedule. A draft Chromic Acid Incident Plan was submitted to EPA in November 1990. The plan was prepared in response to recommendations made following a DOE investigation of an unplanned release of chromic acid solution from Building 444 during 1989. The plan addressed physical and administrative changes to reduce the possibility and impact of future spill events. A number of proposed actions have been completed, and EPA has agreed to refocus the remaining scope of the plan to emphasize issues relevant to surface water protection and source control. A draft plan incorporating the revised approach was submitted to EPA during the second quarter of 1992.

Spill Prevention Control and Countermeasures/Best Management Practices Plan (SPCC/BMP)

The SPCC/BMP is a compilation of existing facility improvements, operational procedures, policies, and requirements for control of hazardous substances and oil spills. A certified draft of the SPCC/BMP was generated in October 1991. The second draft is expected by July 1, 1992, and a final document is expected by October 1992.

Storm Water Permit Application

The RFP, being a site with industrial activity, is required to submit an NPDES storm water permit application under regulations promulgated in November 1990. The original application deadline of November 17, 1991, was changed to October 1, 1992. A network of six storm water monitoring locations was established during 1991 (with the approval of EPA), which will provide storm water quality information for runoff that leaves the core area of Rocky Flats. Automated sampling equipment will allow the collection of flow-composited samples to characterize the runoff, while data loggers will collect and store flow information at each monitoring location.

Colorado Water Quality Control Commission (CWQCC) Water Quality Standards

In September 1991, the CWQCC agreed to hear a petition by DOE to reconsider the classification of Segment 5 of Big Dry Creek. Segment 5, which includes tributaries from source to Ponds A-4, B-5 and C-2, is currently subject to stream standards with goal qualifiers that indicate that the waters are presently not fully suitable but are intended to become fully suitable for the classified use. At the October meeting, DOE/EG&G Rocky Flats, Inc., will ask for an extension of these goal qualifiers and temporary modifications and ask to revise the site-specific organic standards to achieve consistency with the statewide numeric standards for organic chemicals. The CWQCC must take action on the goal standards before February 1993, or the standards now established for Segment 4 (from pond outlets to Standley Lake and Great Western Reservoir) will apply to Segment 5. The hearing is scheduled for October 1992. DOE and EG&G Rocky Flats, Inc., also obtained party status to statewide radionuclide standards hearings held in March 1992.

Compliance Issues

The EPA conducted a Compliance Evaluation Inspection on June 21, 1991, to review the findings of the Compliance Sampling Inspection of February 27-28, 1990. The Summary of Findings attached to the inspection report states that no deficiencies were found at the time of the inspection.

In May 1990 the RFP established the Cross Connection Control Program to meet commitments made by the DOE to the CDH to ensure that RFP fully complies with the Colorado Primary Drinking Water Regulations (CPDWR) pertaining to cross connections. A cross connection exists when a drinking water supply is connected to a possible source of contaminated water without an approved backflow preventor device to stop backflow or backsiphonage of polluted water into the drinking water system. During 1991 the RFP was not in compliance with the CPDWR regarding cross connections; however, work on the program is continuing and EG&G Plant Engineering has made the commitment to provide semiannual progress reports to the CDH.

SAFE DRINKING WATER ACT (SWDA)

The SDWA establishes primary drinking water standards for water delivered by a public water supply system, defined as a system that supplies drinking water to either 15 or more connections or 25 individuals for at least 60 days per year. The RFP water supply system meets these criteria and is termed a noncommunity, nontransient system because persons who use the water do so on a daily basis but do not live at the site.

RFP periodically evaluates plant drinking water for various water quality parameters including primary and secondary water contaminants, inorganics, VOCs, and radionuclides. Results of these analyses are reported to the CDH weekly, monthly, quarterly, and annually depending on the type of analyses performed. A complete description of the Drinking Water Monitoring Program at RFP is given in the 1991 *Rocky Flats Plant Environmental Monitoring Plan* (EG91k).

TOXIC SUBSTANCES CONTROL ACT (TSCA)

The TSCA, administered by the EPA, authorizes testing and regulation of chemical substances that enter the environment. TSCA supplements sections of the CAA, the CWA, and the Occupational Safety and Health Act (OSHA). Compliance with TSCA at the RFP is directed at management of polychlorinated biphenyls (PCBs) and asbestos.

Compliance Issues

In 1991, one 55-gallon drum of nonradioactively contaminated PCB waste was shipped offsite for disposal. Disposal sites for radioactively contaminated PCB wastes are unable to receive RFP waste at this time. RFP is storing radioactively contaminated PCB waste beyond the 1-year storage time limit imposed by TSCA regulations. DOE notified the EPA that storage would be necessary until a commercial or DOE treatment and disposal facility capable of receiving this waste could be identified.

Nonradioactively contaminated asbestos waste is shipped offsite for disposal in a permitted landfill. Radioactively contaminated asbestos waste is being stored onsite until disposal at the Nevada Test Site or until a commercial facility is approved.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

RCRA provides cradle-to-grave control of hazardous waste by imposing management requirements on generators and transporters of hazardous wastes and on owners and operators of treatment, storage, and disposal facilities. The State of Colorado, under authority of the EPA, regulates hazardous waste and the hazardous component of radioactive mixed waste at RFP. EPA retains authority for regulation of Land Disposal Restriction (LDR) wastes. Solely radioactive wastes are regulated by the Atomic Energy Act of 1954 as administered through DOE orders.

RCRA Part A and Part B Permit

The RCRA Part A permit application identifies (1) facility location, (2) owner and operator, (3) hazardous and mixed wastes to be managed, and (4) hazardous waste management methods. A facility that has submitted a RCRA Part A permit application is allowed to manage hazardous wastes under transitional regulations known as interim status pending issuance of a RCRA Operating Permit. The RCRA Part B permit application consists of a detailed narrative description of all facilities and procedures related to hazardous waste management. The RCRA Operating Permit is based on the RCRA Part B permit application and contains specific detailed operating conditions for the waste management units addressed by the permit. RCRA Parts A and B permit applications for RFP cover hazardous waste treatment and storage operations. RFP does not perform hazardous waste disposal.

Part A Permit. Since the early 1980s, a series of RCRA Part A permit applications have been submitted to the CDH. During 1991, the Part A permit application for hazardous and low-level mixed waste was revised twice. Revision 7 was submitted to CDH in June 1991 requesting a change to interim status to operate certain Non-Destructive Assay (NDA) areas and to correct several EPA waste code listings. This request for change to interim status was resubmitted to CDH as Permit Modification Request No. 4 in January 1992. Revision 8 of the Part A permit application for hazardous and low-level mixed waste was submitted in July 1991 and included the new Toxicity Characteristic Leaching Procedure (TCLP) EPA codes and requested low-level mixed waste storage and treatment in two existing Size Reduction Facilities.

The RCRA Part A permit application for transuranic (TRU) mixed waste was revised twice during 1991. Revision 5 was submitted to CDH in June 1991 requesting a change to interim status to operate certain NDA areas and to correct several EPA waste code listings. This request for change to interim status was resubmitted to CDH as Permit Modification Request No. 4 in January 1992. Revision 6 was submitted in July 1991 and included the new TCLP EPA codes.

A major development for the Part A application occurred in August 1991 when the Part A permit application for hazardous and low-level mixed waste (Revision 8) and the Part A permit application for TRU mixed waste (Revision 6) were consolidated and submitted to CDH as the combined hazardous waste, low-level mixed waste, and TRU mixed waste, Part A permit application (Revision 1). This consolidation simplified the Part A application interim status process. Among the items included in the Combined Part A application were four new storage areas for wastes generated by environmental restoration activities. CDH approved some of the changes requested in the Combined Part A in August 1991; however, other requested changes are pending CDH approval.

Two other changes to interim status were requested in a letter during 1991 and did not include a revised Part A permit application. These changes included requests to supercompact low-level mixed waste (August 1991) and to enhance evaporation at the solar ponds (September 1991).

Part B Permit. A significant milestone in RFP's RCRA history occurred in September 1991 when CDH issued the Part B Operating Permit for 9 of 20 hazardous and low-level mixed waste storage units. The permit became effective in October 1991. Three permit modification requests were subsequently submitted to CDH in 1991. Permit Modification Request No. 1 was a Class II modification submitted in October 1991 for changes to the permit's contingency plan, waste analysis plan, and unit descriptions. CDH granted temporary authorization for this permit modification in October 1991, and a public comment meeting was held in

December 1991. This permit modification request was approved by CDH on April 30, 1992. Permit Modification Request No. 2 was a Class I modification submitted to CDH, effective in November 1991, with several administrative errors in the permit corrected. Permit Modification Request No. 3 was a Class I modification submitted in December 1991 and removed an interim compliance date from the training section of the permit in anticipation of revising the training section in 1992.

In October 1989, CDH issued a Notice of Intent to Deny (NOID) for the remaining 11 hazardous and low-level waste storage units. RFP submitted a revised Part B permit application on March 1990 to address these units. This additional information is under review by CDH. The Part B permit application for TRU mixed waste continues to be under review by CDH.

RCRA Closure Plans

RCRA closure plans identify procedures for decontaminating/decommissioning hazardous waste management units from service to prevent both short- and long-term threats to human health and the environment. These plans describe measures to eliminate or minimize future maintenance of hazardous waste management units, to control releases of hazardous constituents, and to permanently close these units. Post-closure monitoring is required if "clean closure" of a unit under RCRA cannot be achieved.

Hazardous waste management facilities that operate under interim status (40CFR265) and facilities that will operate under a permit (40CFR264) must be addressed in RCRA closure plans (40CFR264 and 265, Subpart G). Closure plans for facilities that begin or continue operation following the interim status period must be addressed in the RCRA Part B permit. Land disposal hazardous waste management facilities that discontinue operation during the interim status period and that cannot be "clean closed" in accordance with applicable RCRA regulations, must submit RCRA Part B post-closure care permit applications for interim status units. These are units that have been removed from service but require post-closure monitoring and maintenance.

Closure plans for the Solar Evaporation Ponds (Operable Unit 4 [OU 4]), Present Landfill (OU 7), Original Process Waste Lines (OU 9), and West Spray Field (OU 11) were submitted to CDH in 1986 and 1988. These closure plans have been superseded by the January 1991 Inter-Agency Agreement (IAG). The IAG requires all interim status closure units to use a combination of RCRA and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) criteria. The IAG requires RCRA Facility Investigations/Remedial Investigations (RFI/RI) work plans as a function of characterizing the source of the contamination and the soils of an interim status closure unit. Draft Phase I RFI/RI work plans were submitted to CDH and EPA in 1990 for the Solar Evaporation Ponds, Present Landfill, Original Process Waste Lines, and West Spray Field, and for Other Outside Closures (OU 10) in 1991.

RFP continued groundwater monitoring of OU 4, OU 7, and OU 11 in 1991. Major activities included groundwater and surface water monitoring and installation of new groundwater monitoring wells. The 1990 RCRA annual groundwater monitoring report for OUs was submitted to CDH and EPA on March 1, 1991 (EG91f), and the 1991 RCRA report was submitted on March 1, 1992 (EG92b). The CWQCC held hearings in February 1991 to determine whether the groundwater at RFP should be subject to site-specific standards and classifications. This action was followed by promulgation of standards and classifications on March 15, 1991, becoming effective on April 30, 1991. All unconfined groundwater was made subject to the most stringent surface water standards at RFP. The alluvial aquifers were classified as Domestic Use - Quality, Agricultural Use - Quality and Surface Water Protection. The Arapahoe and Laramie-Fox Hills aquifers were classified Domestic Use - Quality and Agricultural Use - Quality.

A discussion of 1991 compliance activities for remediation of contaminated sites at RFP, including the preparation of remedial investigation work plans, interim remedial action decisions, and project management plans, is provided in Section 4, "Environmental Remediation Programs."

RCRA Contingency Plan

The RCRA Contingency Plan (Part VI of the RCRA Permit) is designed to minimize hazards to human health or the environment from fires, explosions, or any unplanned sudden or nonsudden release of hazardous waste or hazardous waste constituents to air, soil, or surface water. RFP implements the Contingency Plan for the following situations.

- A hazardous waste incident results in an injury requiring more than first-aid.

- A spill, leak, or other release of a hazardous waste to the air, soil, or surface water (i.e., outside a building) if the release is greater than 1 pint or 1 pound.

- A spill, leak, or other release of hazardous waste inside a building results in (1) a release that exceeds a reportable quantity equivalent volume as defined in Title 40CFR302, or (2) a spilled material from a hazardous waste tank system not removed from secondary containment within 24 hours.

- A fire and/or explosion in which a hazardous waste release or an active hazardous waste management unit is involved.

- Situations other than those outlined above at the discretion of the Emergency Coordinator.

In 1991, RFP filed 35 RCRA Contingency Plan Implementation Reports with CDH. These reports described the nature and magnitude of releases, an assessment of actual or potential hazards to human health or the environment, and actions taken to remediate contaminated areas.

Twenty-four Contingency Plan reports documented the release of hazardous substances that were not hazardous wastes before the release. After October 30, 1991, this type of release will not automatically result in implementation of the RCRA Contingency Plan. Of these 24 releases, one release was of mercury (which was contained within a building), one possible release was Di-n-octyl phthalate (analysis confirmed that Di-n-octyl phthalate was not released), and 22 releases were petroleum or antifreeze products (10 of these releases were from private vehicles).

Of the remaining 11 Contingency Plan reports, only two involved the release of a hazardous waste outside a building: (1) approximately 3 quarts of battery acid were released to a paved area from an overturned, used Ni-Cd battery, and (2) approximately 5 gallons of decontamination water containing a minute concentration (< 20 micrograms per liter [µg/l]) of a listed substance (trichloroethene) were released to paved roads from a tanker during transport. The nine remaining reports were for the following incidences.

- Release of approximately 154 gallons of Kathene solution (which contained toxic levels of chromium) from four different events. All of the Kathene releases were contained within Building 707 (four separate reports were filed).

- Release of approximately 750 gallons of process aqueous waste from a RCRA-regulated tank into the secondary containment of Building 731.

- Release of approximately 40 gallons of TRIM™ SOL lubricant mixed with waste oil into a secondary containment pan inside a cargo container within RCRA storage Unit #1.

- Exceedance of the 24-hour requirement to remove a released material (<1 pound of caustic solids) from the secondary containment system in Building 883.

- Compensatory actions taken while operating RCRA units (the process waste transfer system, Units # 40.50 through 40.69, and laundry waste collection tank, Unit

40.16) without adequate secondary containment (two separate reports were filed).

National Response Center (NRC) Notifications

In 1991, per the requirements of 40CFR302.6, RFP notified the NRC of four releases to the environment of a hazardous substance that equaled or exceeded the reportable quantity. All of these releases involved small quantities (<2 gallons) of ethylene glycol/water mixtures. The releases were immediately cleaned up, minimizing impact to the environment. No notifications were made to the Local Emergency Planning Committees (LEPC) or State Emergency Response Commission (SERC) because exposure was limited to persons within the boundaries of the plant.

Waste Minimization

A Waste Minimizaton Program Plan and Pollution Prevention Awareness Plan was submitted to EPA and CDH on September 10, 1991. This plan included projects and building waste minimization and pollution prevention goals.

Radioactive and Mixed Waste. Primary waste generation sources for 1991 involved resumption activities for Buildings 559 and 707, saltcrete production from process waste water treatment, construction projects, and routine maintenance requirements. TRU waste production increased slightly from 77 cubic meters (m^3) in 1990 to 79 m^3 in 1991. TRU waste production in 1989 was 806 m^3. Low-level waste production declined from 3,541 m^3 in 1989 and 1,830 m^3 in 1990 to 1,534 m^3 in 1991. This represents a decline of over 15 percent in radioactive waste production from 1990 to 1991.

Activities to reduce generation of radioactive wastes continued in 1991. Specific projects included the evaluation of a carbon dioxide pellet-blasting system for decontamination work, testing of a hydrocyclone for the removal of particulate in liquid process lines, and the study of more efficient alternatives to current in-line liquid filters. Engineering design began in 1991 for the installation of a uranium chip washer/dryer that will replace the current method of "chip roasting" and land disposal with a method that will allow the chips to be cast into ingots for recycle.

Hazardous Wastes. Hazardous nonradioactive waste generation decreased from 73 m^3 in 1989 and 69 m^3 in 1990 to 53 m^3 in 1991, representing a 23 percent reduction from 1990 to 1991. Waste oil contamination, solvent contamination, and heavy metals (mainly mercury from crushed fluorescent light bulbs) accounted for 45 percent, 22 percent, and 20 percent, respectively, of the hazardous waste generated.

An oil conservation project was initiated in 1991. The intent of the project was to combine oil testing, filtration, and recycling to prevent the generation of oils that will be considered hazardous wastes. Another project initiated in 1991 was aimed at the abatement of releases of ozone depleting chlorofluorocarbons to the atmosphere from plant refrigeration and air conditioning systems. Following are quantities of solvents, garage oils, and coolants that were reclaimed and recycled in 1991.

- 168 kilograms (kg) of RCRA hazardous cleaning solvents
- 1,497 kg of hazardous garage oil
- 4,374 kg of solvents
- 8,836 kg of machine coolant

The garage oil, solvents, and machine coolant were recycled for fuel blending during 1991.

Solid (Nonhazardous) Wastes. The amount of recycled paper increased from 104,420 kg in 1989 and 105,219 kg in 1990 to 170,295 kg in 1991, representing a 62 percent increase from 1990 to 1991. The amounts of garage oil and unregulated machine coolants recycled for fuel blending were 10,927 kg and 6,432 kg, respectively. A moratorium on offsite shipments of scrap metals decreased sales of these metals in 1991. However, 14,733 kg of stainless steel turnings and 55,594 kg of mild steel were sold in 1991.

Two activities to reduce solid waste generation were implemented during 1991. Water saving shower heads were installed in many of the plant's showers, with a goal of reducing water usage by approximately 7.8 million gallons per year. The replacement of disposable serviceware in several of the plant's cafeterias began in 1991. These items continue to be replaced by washable items in an effort to reduce cafeteria waste disposal in the sanitary landfill.

Compliance Issues

Settlement Agreement and Compliance Order on Consent No. 89-10-30-01 (commonly referred to as "Residue Compliance Agreement"). On November 3, 1989, the DOE, CDH, and EPA signed the Settlement Agreement and Compliance Order on Consent No. 89-10-30-01 regarding alleged violations of the RCRA hazardous waste regulations pertaining to proper waste management of residues. RFP submitted documents in compliance with this Consent Order, the last of which was the Mixed Residues Compliance Plan (September 28, 1990).

The Mixed Residues Compliance Plan was prepared to meet the requirements of the Settlement Agreement and Compliance Order on Consent, as well as to provide a schedule for compliance with the conclusions of the United States District Court for the District of Colorado in the Civil Action No. 89–B–181, Sierra Club, Plaintiff, vs. United States Department of Energy, and Rockwell International Corporation, a Delaware Corporation, Defendants. The Mixed Residues Compliance Plan included actions to bring residues into compliance with the Colorado Hazardous Waste Regulations found in 6CCR1007-3 Parts 100, 262, and 265, methods to minimize generation of RCRA-regulated residues, and actions to reduce the amount of RCRA-regulated residues in storage.

In May and June 1990, the Sierra Club amended its 1989 complaint (Civil Action No. 89-B-181) requesting that the court place a permanent or preliminary injunction against the DOE prohibiting the restart of Rocky Flats. This amended complaint alleged that the DOE was not managing hazardous waste at Rocky

Flats in accordance with the RCRA. On August 13, 1991, the United States District Court for the District of Colorado decided in partial favor of the Plaintiff for a permanent injunction in Civil Action No. 89-B-181, Sierra Club, Plaintiff, vs. United States Department of Energy, Defendant, stating that if the DOE does not obtain a permit for the mixed residues currently being stored without a permit or interim status within 2 years of the court judgement, the DOE shall conduct no operations (except for maintenance and safety activities to maintain the safety of Rocky Flats in a nonoperational status) that generate any hazardous waste or mixed radioactive and hazardous waste.

On July 31, 1991, the CDH issued to RFP Compliance Order No. 91-07-31-01, which indicated that the Mixed Residues Compliance Plan was inadequate and therefore violated the November 1989 order. In addition, on August 1, 1991, the CDH filed a complaint in court, alleging that the DOE had submitted an inadequate plan in violation of the November 1989 order and directing the DOE to meet the terms of the Compliance Order. Compliance Order No. 91-07-31-01 specifies a schedule for removing all backlog mixed residues from RFP by January 1, 1999, and a schedule by which mixed residues will be brought into physical and administrative compliance with the Colorado Hazardous Waste Regulations. Activities are in progress to meet the requirements of the Compliance Order and to negotiate a Consent Order for the management of mixed residues.

Federal Facilities Compliance Agreement (FFCA) for Land Disposal Restricted Waste. A compliance order on consent was signed on September 19, 1989, by DOE, EPA Region VIII, and the State of Colorado to provide a 1-year period for DOE to work towards compliance with the land disposal restrictions of the Hazardous and Solid Waste Amendments of 1984 for mixed wastes. The FFCA covers radioactive wastes that were prohibited as of the FFCA effective date, which includes wastes containing solvents and dioxins that do not meet the treatment standards specified by EPA, or "California List" wastes containing hazardous constituents above the applicable allowable levels for land disposal. During the period of the original agreement, DOE was to take all feasible steps to ensure the accurate identification, safe storage, and minimization of restricted waste prohibited from land disposal.

A new agreement, commonly referred to as FFCA-II, was signed on May 10, 1991, by representatives from EPA and DOE. This new agreement is an expansion of the original September 1989 agreement, and again provides the mechanism for DOE to achieve compliance with the LDR portion of the RCRA regulations. FFCA-II is valid for a period of 2 years, during which DOE will continue to put in place those physical and administrative controls necessary to demonstrate compliance with LDR. Specific milestones and schedules will be prepared to demonstrate that proposed activities are planned to bring RFP into compliance with LDR regulations.

During 1991, the State of Colorado received authority from EPA to administer portions of the LDR regulations. Accordingly, a new agreement between DOE and the CDH will be negotiated to replace the existing FFCA-II. This negotiation process is expected to be complete before FFCA-II expires (May 1993).

As with the original agreement, FFCA-II requires submittal of a variety of reports and plans that outline the development and implementation of various treatment technologies to treat mixed wastes before disposal at offsite locations. Submittal of the reports and plans constitutes the primary milestones under the current agreement. Under the terms of the agreement, most of these document submittals are subject to review and/or approval by EPA. These reports and plans are briefly described as follows.

- *Comprehensive Treatment and Management Plan* - This document will describe the justification, selection, and applicability of treatment technologies to LDR wastes at RFP and will include schedules and milestones for developing and implementing chosen technologies. The milestones set forth in the Comprehensive Treatment and Management Plan become enforceable milestones upon approval of the document by EPA.

- *Waste Minimization Plan* - This annual document will discuss current and future initiatives undertaken by RFP to eliminate or minimize the generation of mixed waste.

- *Annual LDR Progress Report* - This document will provide an update and status on the scope and magnitude of LDR mixed waste issues at RFP including quantities of waste in storage, storage locations, progress in LDR determinations and characterization efforts, and treatment technology implementation.

- *Residue Management Report* - This document will describe the plans for bringing the management of mixed residues into compliance with the LDR requirements as a companion document to the Residue Management Plan being prepared under terms of the Residue Compliance Order.

- *Nonradioactive Hazardous Waste Shipping Schedule* - This document will identify the mechanisms and schedules by which existing nonradioactive hazardous wastes can be shipped offsite for disposal.

-*Waste Stream and Residue Identification and Characterization (WSRIC) Report* - This annual document will be a revision to the existing WSRIC prepared in 1990.

The Waste Minimization Plan was submitted in September 1991. All other reports are scheduled for completion in 1992.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)

The CERCLA and its major amendments (Superfund Amendment and Reauthorization Act [SARA]) provide funding and enforcement authority for restoration of hazardous waste sites and for responding to hazardous substance spills. Sites contaminated by past waste activities must be investigated and remediation plans developed and implemented. The intent of these actions is to minimize the release of hazardous waste or other hazardous materials, thereby protecting human health and the environment. CERCLA requirements are addressed in a series of sequential phases intended to identify, design, and complete restoration of contaminated sites. CERCLA activities at RFP are dictated by the IAG.

RFP was added to the National Priorities List (NPL) on October 4, 1989. The NPL is an ordered ranking of CERCLA sites evaluated using the Hazardous Ranking System. If a site scores above a certain threshold level set by EPA, the site is placed on the NPL.

INTER-AGENCY AGREEMENT (IAG)

The IAG was renegotiated early in 1990 following receipt of public and agency comments on the draft agreement submitted for review in December 1989. A revised agreement was published on August 17, 1990. The final agreement, reached in January 1991 and signed by EPA, CDH, and DOE, included the following revisions.

- OUs were reordered to emphasize priority of offsite areas (i.e., areas located east of Indiana Street).

- The number of OUs was increased from 10 to 16 to better focus on the unique characteristics of different restoration areas (Table 2-3).

The IAG clarifies EPA, CDH, and DOE regulatory roles, coordinates oversight efforts and corrective actions, standardizes requirements, and ensures compliance with orders and permits. The agreement also specifies delivery of major reports, project management activities and milestones, and includes community involvement and decision making responsibilities. The IAG establishes a procedural framework and schedule through which response actions are developed, implemented, and monitored in accordance with CERCLA, RCRA, and the Colorado Hazardous Waste Act.

Documents prepared in accordance with the IAG cover a range of topics including remedial investigation work plans, interim remedial action decisions, community survey plans, project management plans, and health and safety plans. A series of monthly and quarterly Environmental Compliance Action reports document progress against IAG milestones (DOE91g, DOE91h). Table 2-4 lists IAG milestones completed in 1991. Section 4, "Environmental Remediation Programs," describes remediation activities accomplished at RFP during 1991.

Remediation Goals

The CERCLA requires that remediation goals comply with applicable or relevant and appropriate requirements (ARARs) of federal laws or more stringent promulgated state laws in relation to cleanup standards. ARARs are generally dynamic in nature in that they evolve from general to very specific during the CERCLA Remedial Investigation/ Facilities Study (RI/FS) process. Final remediation objectives are comprised of both ARARs and risk assessment information and will be determined in the Record of Decision (ROD). The development of cleanup standards at RFP follow the general procedures described below.

Table 2-3
Former and Current Prioritization of Operable Units by the IAG

Former Operable Unit (OU) Number	OU Number Under Final IAG (effective 1-11-91)	Description
01	01	881 Hillside Area
02	02	903 Pad Area
10	03	Offsite Areas
03	04	Solar Ponds
04	05	Woman Creek
04	06	Walnut Creek
03	07	Present Landfill
05	08	700 Area
03	09	Original Process Waste Lines
03	10	Other Outside Closures
03	11	West Spray Field
06	12	400/800 Area
07	13	100 Area
09	14	Radioactive Sites
03	15	Inside Building Closures
08	16	Low-Priority Sites

Table 2-4

IAG Milestones Completed in 1991

IAG Milestone	Operable Unit
Final RS[a] and Final IM/IRA[b] Decision Document	02
Final Community Relations Plan	Sitewide
Draft Phase II RFI/RI[c] Work Plan (Bedrock)	02
IM/IRA Implementation Document	01
Final Standard Operation Procedures	Sitewide
Final SOPs Addendum for OU 1 Phase II RFI/RI Work Plan	Sitewide
Final Quality Assurance Project Plan	Sitewide
Final SOPs Addendum for OU 2 Phase II RFI/RI Work Plan	Sitewide
Begin Phase II-A IM/IRA Construction	01
Final Past Remedy Report	03
Draft Work Plan for Discharge Limits for Radionuclides	Sitewide
Draft Phase I RFI/RI Work Plan	05
Final Historical Information and Preliminary Health Risk Assessment Report	03
Draft Phase I RFI/RI Work Plan	06
Field Treatability Test System Installation Complete	02
Final Treatability Study Plan	Sitewide
Community Relations Plan Responsiveness Summary	Sitewide
Final Phase II RFI/RI Work Plan (Bedrock)	02
Draft Phase I RFI/RI Work Plan	03
Final Plan for Prevention of Contaminant Dispersion	Sitewide
IM/IRA Testing	01
Final Phase I RFI/RI Work Plan	07
Final Phase I RFI/RI Work Plan	05
Begin Phase II-B IM/IRA Construction	01
Final Work Plan for Discharge Limits for Radionuclides	Sitewide
Final Phase I RFI/RI Work Plan	06
Responsiveness Summary on PPCD[d]	Sitewide
Final Phase I RFI/RI Work Plan	04
Final Phase I RFI/RI Work Plan	09
Draft Phase I RFI/RI Work Plan	10
Final Phase I RFI/RI Work Plan	03

a. Responsiveness Summary
b. Interim Measures/Interim Remedial Action
c. RCRA Facility Investigation/Remedial Investigation
d. Plan for Prevention of Contaminate Dispersion

Initially, during the RFI/RI work plan stage, potential chemical-specific ARARs are identified, usually based on a limited amount of data. Chemical-specific ARARs at this point have meaning only in that they may be used to establish appropriate detection limits so that data collected during the RFI/RI may be compared to ARAR standards. As more information becomes available during the RFI/RI stage, chemical-specific ARARs may become more refined as constituents are added or deleted. Detailed location-specific ARARs are proposed in the RFI/RI report as the result of the RFI/RI process. This is followed by action-specific ARARs and remediation goals that are identified through the Corrective Measures Study/Feasibility Study (CMS/FS). A discussion is provided in the CMS/FS report for each remedial alternative regarding the rationale for all ARAR determinations. Once a preferred remedial action alternative is formally selected in the ROD, all chemical-, location-, and action-specific ARARs are also defined in final form. CERCLA requires that remediation programs attain ARARs and are protective of human health and the environment.

EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT (EPCRA)

EPCRA was enacted as a freestanding provision of the SARA in 1986. EPCRA, also known as SARA Title III, requires facilities to notify state and local emergency planning entities of the presence of potentially hazardous substances in their facilities and to report on the inventories and environmental releases of those substances. The intent of these requirements is to provide the public with information on hazardous chemicals in their communities, enhancing public awareness of chemical hazards, and facilitating development of state and local emergency response plans.

Sections 301 and 302

Under Sections 301 and 302, the EPA requires the establishment of State Emergency Response Commission (SERC), which are responsible for the formation of emergency planning districts, and Local Emergency Planning Committee (LEPC). Also under these requirements, facilities that produce, use, or store listed extremely hazardous substances above the threshold planning quantity must notify the SERC and the LEPCs. RFP participates in the activities of the LEPCs established under these sections for emergency planning at the county level of government. RFP also maintains an emergency preparedness document for the plant and conducts annual mock emergency response scenarios to determine the effectiveness of the plan and the ability of plant directorates to respond.

Section 304

Section 304 applies to releases of extremely hazardous substances that exceed their reportable quantities and have the potential for impact beyond the plant boundaries. If the release is determined not to pose a potential impact beyond the plant boundaries, then reporting is not required under SARA Section 304; however, since a chemical may be listed on both the Extremely Hazardous Substances list under SARA and the CERCLA Hazardous Substances list, reporting may still be required under CERCLA Section 103(d) to the National Response Center, EPA, and CDH. When a release occurs that is subject to Section 304, the facility owner or operator must notify the state and local emergency planning committee immediately by phone and again in writing as soon as practicable. Section 304 requirements apply specifically to facilities such as RFP that produce, use, or store one or more hazardous chemicals as defined by the OSHA Hazard Communication Standard. The Permitting and Compliance group of RFP's Waste Programs Department makes these notifications if such releases occur.

In 1991 there were no reportable releases of extremely hazardous substances or CERCLA hazardous substances that posed a potential impact beyond RFP boundaries.

Section 311

Under Section 311, facilities must submit to the SERC, LEPC, and the fire department, copies of Material Safety Data Sheets (MSDSs) or a list of all chemicals above certain thresholds that are defined as hazardous by the OSHA Hazard Communication Standard. After the initial submittal, Section 311 requires the submittal of updates within 3 months for new chemicals that become subject to the OSHA Hazard Communication Standard or after discovering new information. This information was provided to the SERC, LEPC, and the fire department by RFP's Industrial Hygiene Department in 1987 to meet the original requirements; MSDS updates were provided to these agencies when required.

Section 312

Section 312 of EPCRA requires facilities to prepare an annual report titled "Tier II Emergency and Hazardous Chemical Inventory Forms," listing the quantities and locations of hazardous chemicals, or a "Tier I" chemical list report. This section covers hazardous chemicals under OSHA's Hazard Communication Standard (with limited exceptions) that are stored at a facility in excess of 10,000 pounds or in excess of a chemical-specific listed Threshold Planning Quantity. Any facility required to prepare or have available an MSDS for a hazardous chemical under OSHA's Hazard Communication Standard must submit Tier I information on a form or, if requested or in lieu of Tier I submittal, Tier II information to the SERC, LEPC, and the local fire department. The Tier I or Tier II information must be submitted annually, beginning on March 1, 1988. RFP submitted this report to the following agencies for the calendar year 1990 report: Colorado Emergency Planning Commission, Jefferson County Emergency Planning Committee, Boulder County Emergency Planning Committee, and the Rocky Flats Fire Department (jurisdictional fire department).

Section 313

Section 313 of EPCRA requires that facilities prepare an annual report titled "Toxic Chemical Release Inventory, Form R," if annual usage quantities of listed toxic chemicals exceed certain thresholds. Following were the threshold chemical usage quantities for 1991.

- 25,000 pounds for listed chemicals either manufactured or processed
- 10,000 pounds for listed chemicals otherwise used

Facilities must report quantities of both routine and accidental releases of listed chemicals, maximum amount of the listed chemical stored onsite during the calendar year, and amount contained in waste transferred offsite. The owner or operator of the facility on the reporting date, July 1 of each year, is primarily responsible for reporting the data for the previous year's operations at that facility. Any other owner or operator of the facility from January 1 of the data generation year to June 30 of the reporting year may also be held liable. RFP submitted this report to the

EPA and to the State of Colorado in 1991 detailing the chemicals used in 1990 (Table 2-5). Chemical usage for 1989 is also reported in Table 2-5 for comparison purposes.

Table 2-5

Chemicals and Quantities (lbs) Used in 1989 and 1990 as Reported on Form R Reports

Chemical	1989	1990
Nitric acid	223,387	10,244
Sulfuric Acid	58,300	-
Carbon tetrachloride	48,212	-
1,1,1-trichloroethane	45,634	-
Phosphoric acid	44,195	-
Hydrochloric acid	27,575	12,785
Ethylene glycol	13,423	-
Freon 113	12,545	-

Carbon tetrachloride and Freon 113 were used in decreasing quantities at RFP between 1988 and 1990 as a result of waste minimization efforts and the curtailment of plant operations and were used in quantities less than 10,000 pounds in 1990. Many chemicals reported in 1988 and 1989 do not appear on the 1990 list because of the suspension of plutonium operations.

AGREEMENT IN PRINCIPLE (AIP)

An AIP was executed between DOE and the State of Colorado on June 28, 1989. This agreement identified additional technical and financial support by DOE to Colorado for environmental oversight, monitoring, remediation, emergency response, and health-related initiatives associated with the RFP. The agreement also addressed RFP environmental monitoring initiatives and accelerated cleanup where contamination may present an imminent threat to health or the environment. The agreement is designed to ensure citizens of Colorado that public health, safety, and the environment are being protected through accelerated existing programs and substantial new commitments by DOE, and through vigorous programs of independent monitoring and oversight by Colorado officials.

Programs and projects put into place under this agreement include the air emissions inventory (see Clean Air

Act above) and concurrent sampling of pond discharges (see Clean Water Act above) and the Rocky Flats Toxicological Review and Dose Reconstruction Study. This latter study, being conducted by CDH, is intended to examine chemical and radionuclide emissions from RFP and assess what health impacts, if any, may have occurred to the public. A draft report on the history of operations at RFP was completed in February 1992 as part of this study (CDH92).

SPECIAL ASSIGNMENT TEAM

On June 6, 1989, DOE mobilized a Special Assignment Team (Tiger Team) to provide an independent audit of operations and practices at RFP. This followed initiation of a search warrant by EPA based on an affidavit alleging regulatory and criminal violations of environmental law at RFP. The United States Department of Justice is conducting the investigation, and a federal grand jury has been convened to review RFP compliance with applicable environmental laws.

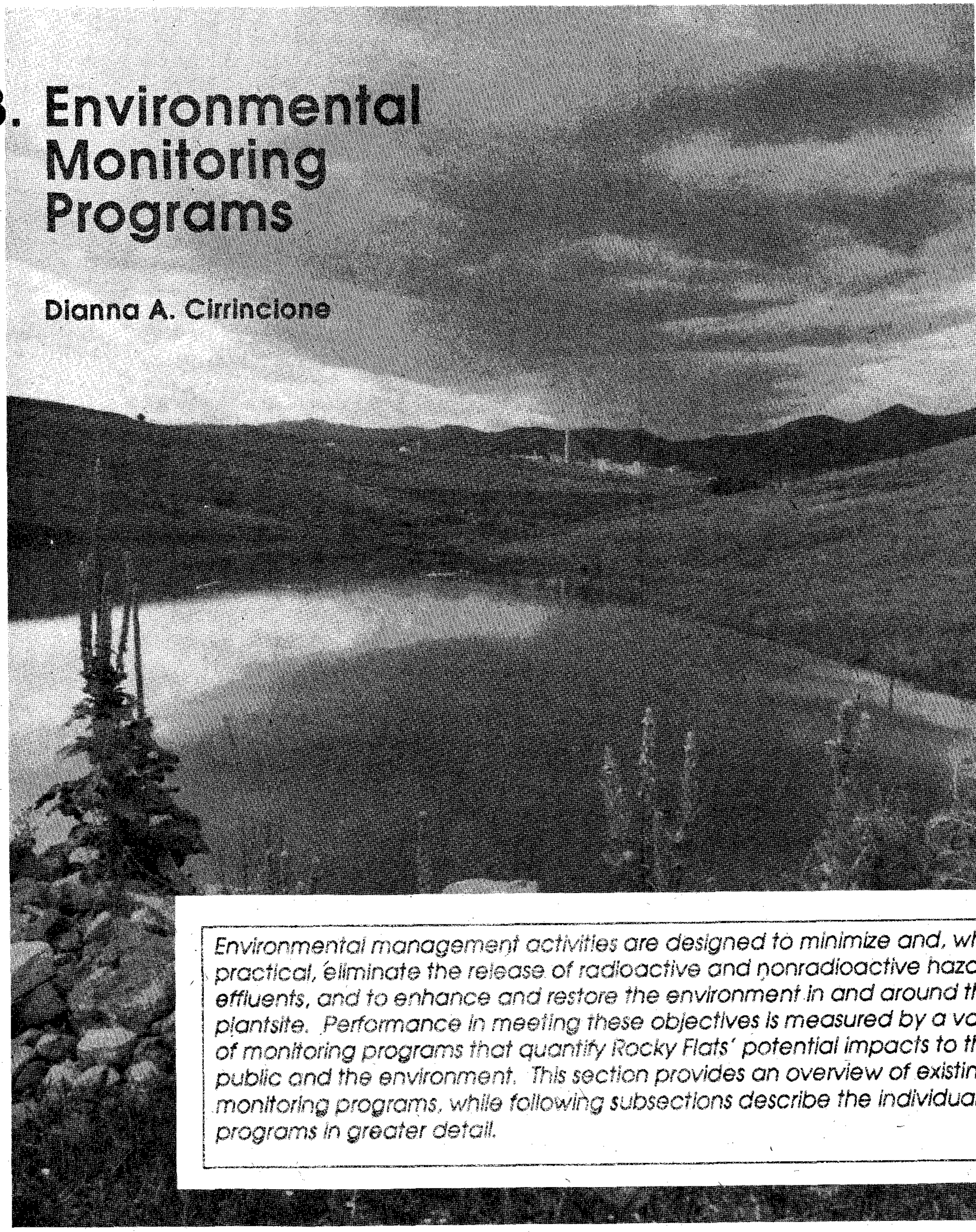
The environmental audit was completed on July 21, 1989, and results were reported in the *Assessment of Environmental Conditions at the Rocky Flats Plant* (DOE89). EG&G Rocky Flats, Inc., responded to findings of the Special Assignment Team in the *Corrective Action Plan in Response to the August 1989 Assessment of Environmental Conditions at the Rocky Flats Plant* (EG90c). This document outlines 93 separate action plans that contain descriptions of measures to be taken by RFP to address findings and includes schedules, milestones, associated costs, and parties responsible for implementing planned actions. Many of the activities described in this plan overlap or are similar to actions specified in the AIP and IAG described above and to the RFP Five-Year Plan (FYP) for environmental and waste programs (EG91c). Progress concerning these action plans has been described in quarterly reports titled *DOE Quarterly Environmental Compliance Action Report* (DOE91h). The Commitments Tracking System operated by EG&G Rocky Flats, Inc., monitors the status of action plans. Plan status may be "open," meaning that work continues on one or more tasks within an action plan; "in verification," meaning that the plan manager has certified that plan activities are complete and this is being verified; "reopened," meaning that not all plan tasks were verified as complete and further work is required; and "verified complete," meaning that all tasks have been completed and verified. As of December 1991, 34 action plans were verified as complete, 29 plans were in verification, and 30 plans were open.

SETTLEMENT AGREEMENT (Church vs. DOE, et al.)

A settlement agreement among DOE, The Dow Chemical Company, Rockwell International, local governments, and private landowners was reached in July 1985, requiring remediation actions to reduce plutonium contamination on areas adjacent to the eastern boundary of RFP. Contamination originated from the area now designated as the 903 Pad and occurred through airborne dispersion of plutonium particles. Soils analyses revealed offsite plutonium levels that exceed the Colorado standard of 2 disintegrations per minute per gram (dpm/g) (0.9 picocuries per gram [0.9 pCi/g]), although the EPA screening level of 44.4 dpm/g (20.0 pCi/g) was not exceeded. Court-ordered remedial action was designated for 350 acres through plowing and revegetation to prevent resuspension of the plutonium. Legal ownership of these contaminated lands was transferred to Jefferson County and the city of Broomfield for reservoir expansion and open space (no public access is permitted). Approximately 120 acres of Jefferson County land have been treated by plowing, tilling, and seeding. Plutonium levels for these areas are now within state limits. Revegetation measures, including seeding and mulching, were conducted on plowed areas during 1991 (EG91a). Evaluation of revegetation success and weed control to encourage growth of desirable plant species will be conducted during 1992.

3. Environmental Monitoring Programs

Dianna A. Cirrincione



Environmental management activities are designed to minimize and, where practical, eliminate the release of radioactive and nonradioactive hazardous effluents, and to enhance and restore the environment in and around the plantsite. Performance in meeting these objectives is measured by a variety of monitoring programs that quantify Rocky Flats' potential impacts to the public and the environment. This section provides an overview of existing monitoring programs, while following subsections describe the individual programs in greater detail.

OVERVIEW

RFP conducts operations that involve or produce liquids, solids, and gases containing radioactive and nonradioactive potentially hazardous materials. RFP environmental programs monitor penetrating ionizing radiation and pertinent radioactive, chemical, and biological pollutants. Data on air, surface water, groundwater, and soils provide information to assess immediate and long-term environmental consequences of normal and unplanned effluent discharges and actual or potential exposures to critical populations. Site-specific data are used to evaluate risk to humans and to assist in the warning of unusual or unforeseen conditions. Routine reports to local, state, and federal agencies and to the public provide information on the performance of these programs in maintaining and improving environmental quality and public health and safety at RFP. Table 3-1 is a list of these reports. Table 3-2 lists the primary environmental compliance standards for environmental monitoring programs at RFP. Additional compliance standards for air, surface water, and groundwater programs are given under references EG91o, EG92a, and EG91n, respectively.

The *Environmental Monitoring Plan* (EG91k) describes RFP environmental monitoring programs. These programs provide current information on impacts to the environment and characterize environmental degradation at sites throughout RFP to identify contaminated sites and to design and monitor restoration activities. Sections 3.1 through 3.6 of this report summarize results of routine environmental monitoring programs at RFP in 1990. Appendix D gives a detailed explanation of the sampling procedures used by laboratories and defines detection limits and error term propagation. Results are commonly compared to appropriate guides and standards that establish limits for radioactive and nonradioactive effluents. Readers unfamiliar with these standards are encouraged to review Appendix B, "Applicable Guides and Standards."

In addition to environmental programs performed by EG&G Rocky Flats, Inc., several local, state, and federal governmental agencies conduct independent audits and environmental surveys within and adjacent to RFP. CDH, DOE, and the cities of Broomfield and Westminster conduct various air, water, and soil monitoring programs. Data are reported collectively at monthly Environmental Monitoring Information Exchange Meetings. RFP provides monthly environmental monitoring summaries at these meetings, which are open to the public and have been ongoing since the early 1970s.

Table 3-1
RFP Environmental Reports

Regulatory Report [a]	Agency [b]	Frequency
Air Compliance Report (40 CFR 61.94)	EPA	Annual
Effluent Information System/Onsite Discharge Information System	DOE	Annual
Environmental Protection Implementation Plan	DOE	Annual
Emergency and Hazardous Chemical Inventory Forms (Tier II)	c	Annual
Toxic Chemical Release Inventory (Form R)	EPA	Annual
National Pollution Discharge Elimination System/Discharge Monitoring Report	EPA	Monthly/ Annual
Polychlorinated Biphenyls (PCB) Inventory	EPA	Annual
Resource Conservation and Recovery Act Groundwater Monitoring Report	EPA/CDH	Annual
Rocky Flats Monthly Environmental Monitoring Report	DOE/EPA/CDH/ County/City	Monthly
Rocky Flats Plant Site Environmental Report	DOE	Annual
Environmental Monitoring Plan	DOE	Annual
Air Quality Management Plan	DOE	Annual
Surface Water Management Plan	DOE	Annual
Groundwater Protection and Monitoring Program Plan	DOE	Annual
Background Geochemical Characterization Report	EPA/CDH	Annual

a. Reports on major environmental programs prepared on a periodic basis
b. EPA - Environmental Protection Agency; DOE -Department of Energy; CDH - Colorado Department of Health;
County - Jefferson
Cities - Arvada, Broomfield, Westminster, Denver, Boulder, Northglenn, Fort Collins
c. Colorado Emergency Planning Commission
Jefferson County Emergency Planning Committee
Boulder County Emergency Planning Committee
Rocky Flats Fire Department

Table 3-2
Primary Compliance Standards for Environmental Monitoring Programs

Monitoring Program	Compliance Standards
AIR	
Effluent Air	• National Emission Standards for Hazardous Air Pollutants (Title 40CFR61)
	• Colorado Air Quality Control Regulation #8 (Title 5CCR1001)
	• General Environmental Protection Program (DOE Order 5400.1)
	• Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
Nonradioactive Ambient Air	• National Ambient Air Quality Standards (Title 40CFR50)
	• Colorado Air Quality Control Regulations #1, #2, and #3 (Title 5CCR1001)
	• General Environmental Protection Program (DOE Order 5400.1)
	• Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
Radioactive Ambient Air	• General Environmental Protection Program (DOE Order 5400.1)
	• Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
SURFACE WATER	
Surface Water	• National Pollutant Discharge Elimination System (Title 40CFR 22, 125)
	• Colorado Water Quality Control Commission Surface Water Standards (Title 5CCR1000)
	• General Environmental Protection Program (DOE Order 5400.1)
	• Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
Community Water	• National Interim Primary Drinking Water Regulations (Title 40CFR141)
	• Colorado Primary Drinking Water Regulations (Title 5CCR1002)
	• General Environmental Protection Program (DOE Order 5400.1)
	• Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
GROUNDWATER	• Comprehensive Enviornmental Response, Compensation and Liability Act (Title 42 U.S.C. 9601)
	• Resource Conservation and Recovery Act (Title 42 U.S.C. 6901)
	• Colorado Hazardous Waste Management Act (Title 25 CRS, Article 15)
	• General Environmental Protection Program (DOE Order 5400.1)
	• Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
	• Colorado Water Quality Control Commission Groundwater Standards
SOILS	• United States Atomic Energy Commission Rocky Flats Plant, 1973 Environmental Surveillance Summary Report
	• General Environmental Protection Program (DOE Order 5400.1)
	• Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
RADIATION DOSE	• Radiation Protection of the Public and the Environment (DOE Order 5400.5)
	• General Environmental Protection Program (DOE Order 5400.1)
	• Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)

THE FIVE-YEAR PLAN (FYP) AND THE SITE-SPECIFIC PLAN (SSP)

The purpose of the FYP is to establish an agenda for compliance and cleanup against which progress will be measured. The plan is revised annually, with a 5-year planning horizon, and supports an annual national plan that is issued under the same title. A draft plan for fiscal years 1994-1998 was prepared in February 1992 and is titled *Rocky Flats Plant FY94-98 Five-Year Plan* (EG92c). The FYP encompasses total program activities and costs for DOE Corrective Activities, Environmental Restoration, Waste Management, and Applied Research and Development. Hazardous, radioactive, mixed (hazardous and radioactive), and sanitary wastes are addressed, along with facilities and sites that are either contaminated with wastes or used in the management of those wastes.

To describe how activities shown in the FYP would be implemented at RFP, an SSP is prepared. This plan is revised annually and emphasizes near-term activities, primarily those to be accomplished in a fiscal year. Final plans for 1991 (EG91b) and 1992 (EG91j) have been prepared.

3.1 Meteorological Monitoring and Climatology

Regina A. Deola

This section presents meteorological data collected at the Rocky Flats Plant from January 1 through December 31, 1991, from instrumentation installed on a 61-meter (200-foot) tower (pictured) located in the west buffer zone. The tower is instrumented at 10, 25, and 60 meters to measure horizontal wind speed, direction, vertical wind speed, and temperature. Dew point measurements are made at the 10-meter level. Solar radiation measurements are taken by a radiometer mounted on an unobstructed platform at 1.5 meters above ground level. Ground-level precipitation and pressure are also measured.

Monitoring Results

The meteorological monitoring program supports various operations at the RFP. Meteorological information is necessary for (1) assessing transport and diffusion characteristics of the atmosphere used in emergency response and environmental impact assessment, (2) designing other environmental monitoring networks, and (3) developing site-specific weather forecasts. Meteorological data are also used for climatological analyses, hydrological studies, and various design-base engineering studies.

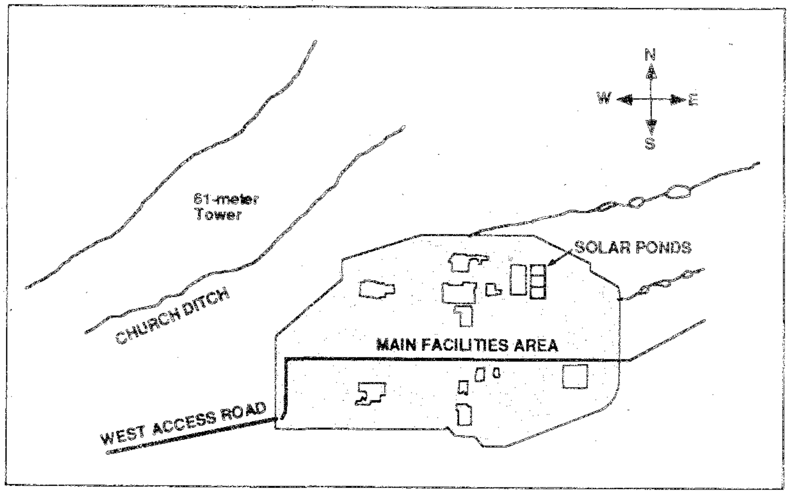


Figure 3.1-1. Location of the RFP 61-Meter Meteorological Tower

The meteorological data included in this report represent 98 percent data recovery from the 61-meter tower located to the northwest of the main plant (Figure 3.1-1). Table 3.1-1 is the annual climatic summary compiled for 1991. The 1991 climograph of this data is represented in Figure 3.1-2.

Table 3.1-1
1991 Annual Climatic Summary

Month	Temperatures (°F) High	Low	Mean	Dewpoint Mean	Precipitation (inches) Total	Wind Data Mean	Maximum	Pressure Mean
January	55.9	-5.8	29.8	11.3	0.19	10.7	72.7	809
February	58.3	14	40.5	13.8	0.04	9.4	60.2	812
March	64.4	16.9	39.7	-999	0.41	11.6	83.7	804
April	68.4	16.5	42.1	22.3	1.5	8.9	53	808
May	79.7	27.7	55.0	31.3	3.77	8.7	47.9	810
June	91.6	45.0	64.4	39.6	2.3	7.6	40.7	813
July	90.5	50.9	68.7	45.5	2.47	7.2	41.2	818
August	86.2	52.2	67.8	48.0	2.45	6.9	46.1	819
September	79.7	34.7	59.7	36.7	0.84	7.4	49	813
October	82.9	3.5	49.8	23.5	0.31	8.1	46.8	813
November	66.9	-2.7	36.1	18.3	1.72	9.2	69.3	811
December	63.0	5.7	36.3	12.9	0.06	8.7	65.1	811

Annual Mean Temperature	49.17 °F
Annual Precipitation	16.06 Inches
Annual Average Wind Speed	8.7 Miles per Hour
Maximum Wind Speed Gust	83.7 Miles per Hour

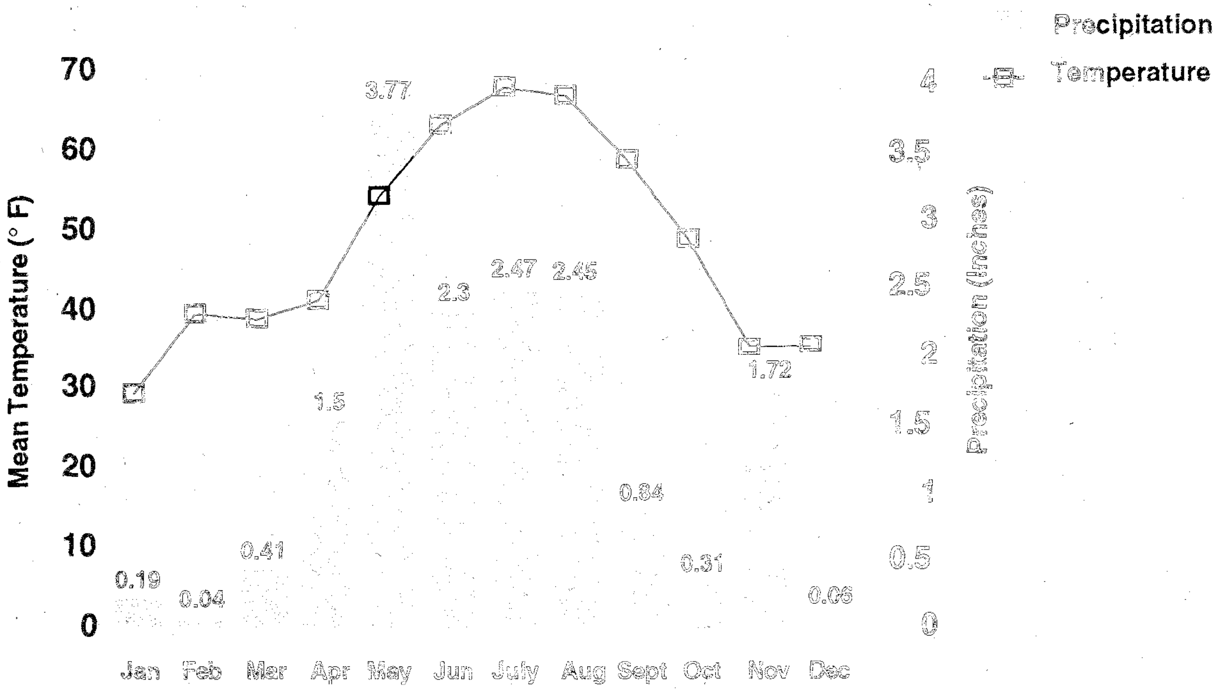


Figure 3.1-2. 1991 Climograph for the Rocky Flats Plant

The annual average temperature for the RFP was 49.2 °F. The temperature extremes ranged from a minimum of -5.8 °F on January 29 to a maximum of 91.6 °F on the afternoon of June 25. The peak wind gust of 83.7 miles per hour for the year occurred on March 3. A deluge of precipitation occurred on August 6 when 1.15 inches of rain and hail fell within a 2-hour period. The greatest amount of precipitation that fell over a 24-hour period was 1.32 inches, which occurred between the morning of June 1 and the morning of June 2.

The meteorology of RFP is strongly influenced by topography. The proximity of the Rocky Mountains and High Plains produce a diurnal cycle to the wind patterns when there are no strong storm systems around Colorado. The east-west running canyons to the west of the RFP can further channel the local wind conditions. The wind generally blows downslope from the mountains to the plains at night; however, daytime wind directions are nonpreferential. The South Platte River Valley is the area for the confluence and divergence of the airflow patterns for the region between the Front Range and the Denver Metropolitan area. Chinook windstorms may occur during the late winter and spring as winds moving from west to east over the continental divide plunge down the east side of the mountain slopes. Winters are relatively mild. The climate is also characterized by wet springs and frequent thunderstorms during the summer.

Table 3.1-2 is the annual summary of the wind direction frequency distribution divided by wind speed categories at the RFP. These data are represented graphically in Figure 3.1-3. Compass point designations indicate the true bearing when facing the wind (wind along each vector blows toward the center). Northwest winds are predominant at the RFP.

Table 3.1-2

Wind Direction Frequency (Percent), by Four Wind-Speed Classes, at the Rocky Flats Plant

(15 - Minute Averages - Annual 1991)

	Calm	1-3 (meters/sec)	3-7 (meters/sec)	7-15 (meters/sec)	>15 (meters/sec)	Total
	2.23					2.23
N	-	2.86	3.85	0.01	0.00	7.00
NNE	-	2.79	2.63	0.25	0.00	5.67
NE	-	2.97	1.56	0.04	0.00	4.57
ENE	-	2.30	0.92	0.02	0.00	3.23
E	-	2.52	0.91	0.01	0.00	3.44
ESE	-	2.83	0.90	0.00	0.00	3.73
SE	-	2.77	1.98	0.00	0.00	4.85
SSE	-	2.49	2.53	0.27	0.00	5.29
S	-	2.50	2.68	0.24	0.00	5.42
SSW	-	2.36	2.28	0.19	0.00	4.82
SW	-	2.50	3.13	0.19	0.00	5.82
WSW	-	2.66	4.19	0.80	0.00	7.65
W	-	3.26	3.21	2.12	0.34	8.93
WNW	-	3.16	4.34	4.25	0.24	11.99
NW	-	3.18	4.17	1.26	0.01	8.62
NNW	-	2.74	3.84	0.16	0.00	6.74
TOTALS	2.23	43.89	43.12	10.18	0.59	100.0

Figures 3.1-4 and 3.1-5 portray the diurnal pattern of the wind distribution mentioned in the previous section. Day and night were differentiated monthly by using the average sunrise and sunset time of each month. Easterly components of the wind differ between day and night periods. The wind comes from the North-

and spring as winds moving from west to east over the continental divide plunge down the east side of the mountain slopes. Winters are relatively mild. The climate is also characterized by wet springs and frequent thunderstorms during the summer.

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	2.23					2.23
N	-	2.86	3.85	0.01	0.00	7.00
NNE	-	2.79	2.63	0.25	0.00	5.67
NE	-	2.97	1.56	0.04	0.00	4.57
ENE	-	2.30	0.92	0.02	0.00	3.23
E	-	2.52	0.91	0.01	0.00	3.44
ESE	-	2.83	0.90	0.00	0.00	3.73
SE	-	2.77	1.98	0.00	0.00	4.85
SSE	-	2.49	2.53	0.27	0.00	5.29
S	-	2.50	2.68	0.24	0.00	5.42
SSW	-	2.36	2.28	0.19	0.00	4.82
SW	-	2.50	3.13	0.19	0.00	5.82
WSW	-	2.66	4.19	0.80	0.00	7.65
W	-	3.26	3.21	2.12	0.34	8.93
WNW	-	3.16	4.34	4.25	0.24	11.99
NW	-	3.18	4.17	1.26	0.01	8.62
NNW	-	2.74	3.84	0.16	0.00	6.74
TOTALS	2.23	43.89	43.12	10.18	0.59	100.0

Figures 3.1-4 and 3.1-5 portray the diurnal pattern of the wind distribution mentioned in the previous section. Day and night were differentiated monthly by using the average sunrise and sunset time of each month. Easterly components of the wind differ between day and night periods. The wind comes from the North-

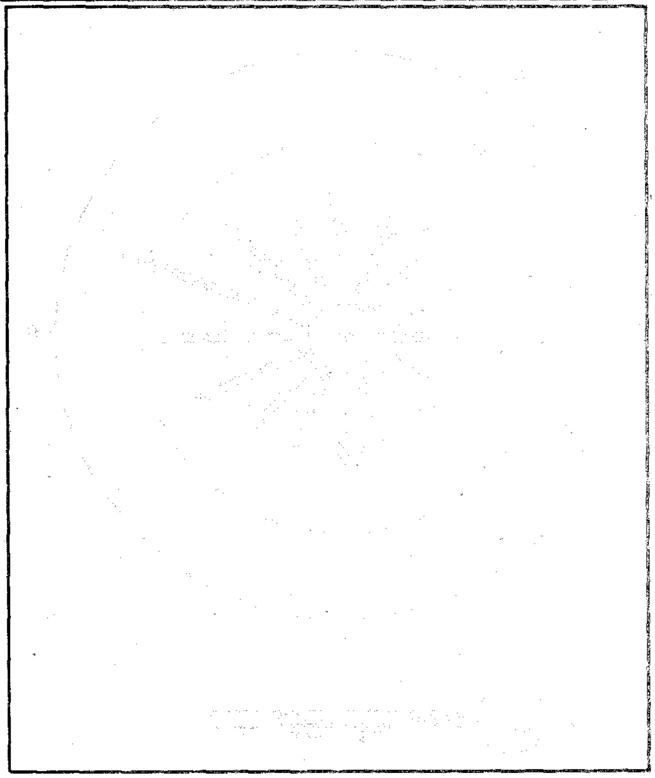


Figure 3.1-3. RFP 1991 Wind Rose - 24-Hour

Northeast (NNE) sector through the South-Southeast (SSE) sector approximately 47 percent of the time during the day. The reverse wind sector (South-Southwest [SSW] through North-Northwest [NNW]) percentage is 39 percent during the day. The dominant nighttime flow is from the SSW through NNW sector with over 74 percent occurrence.

Pasquill-Gifford stability classes are calculated for use in atmospheric dispersion estimates. Stability classes at RFP were calculated using the Sigma Phi technique, which categorizes the class of stability as a function of the standard deviation of vertical wind speed and the mean horizontal wind speed. The class categories range from

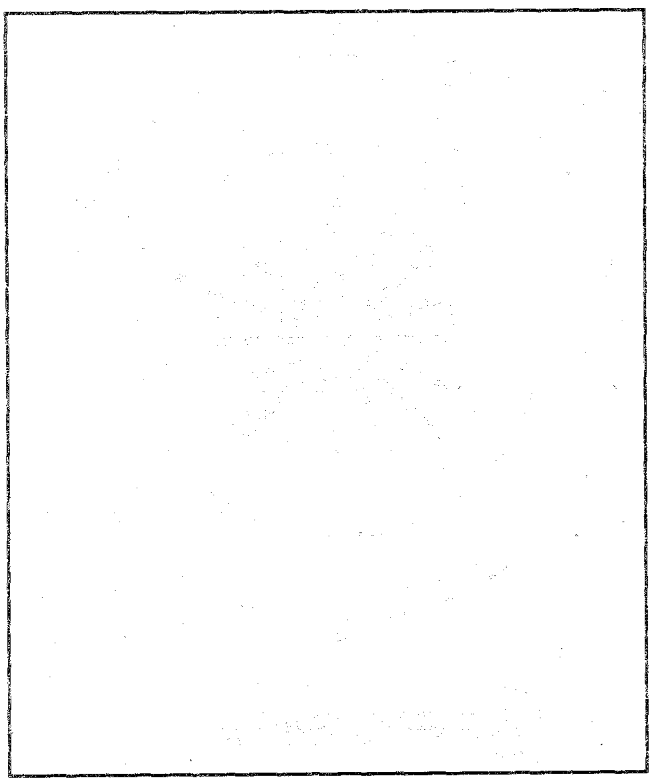


Figure 3.1-4. RFP 1991 Wind Rose - Day

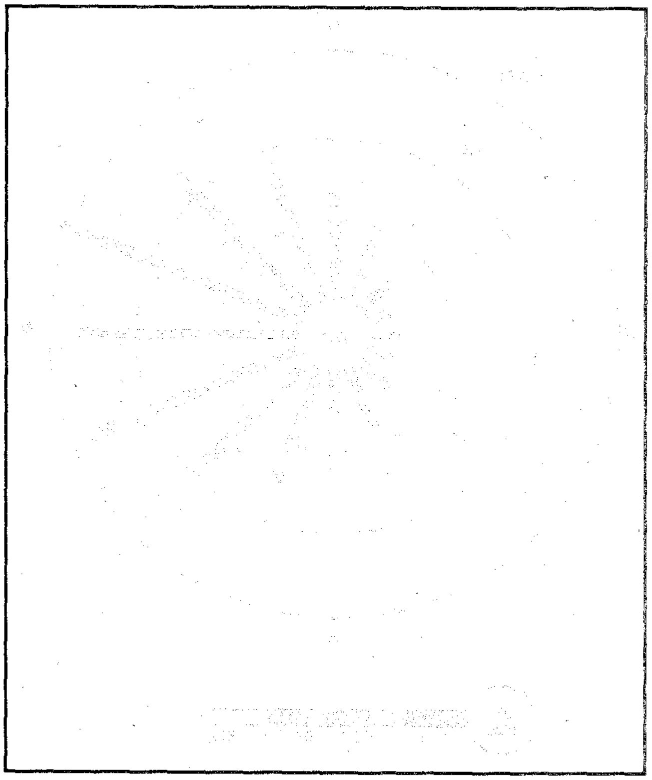


Figure 3.1-5. RFP 1991 Wind Rose - Night

A to F, extremely unstable to moderately stable, respectively. The D class represents neutral stability characteristics. By definition, the stability class is evaluated as neutral when the average wind speed is greater than or equal to 6 meters per second (m/s). Table 3.1-3 shows the percentage of occurrence of stability classes at the RFP.

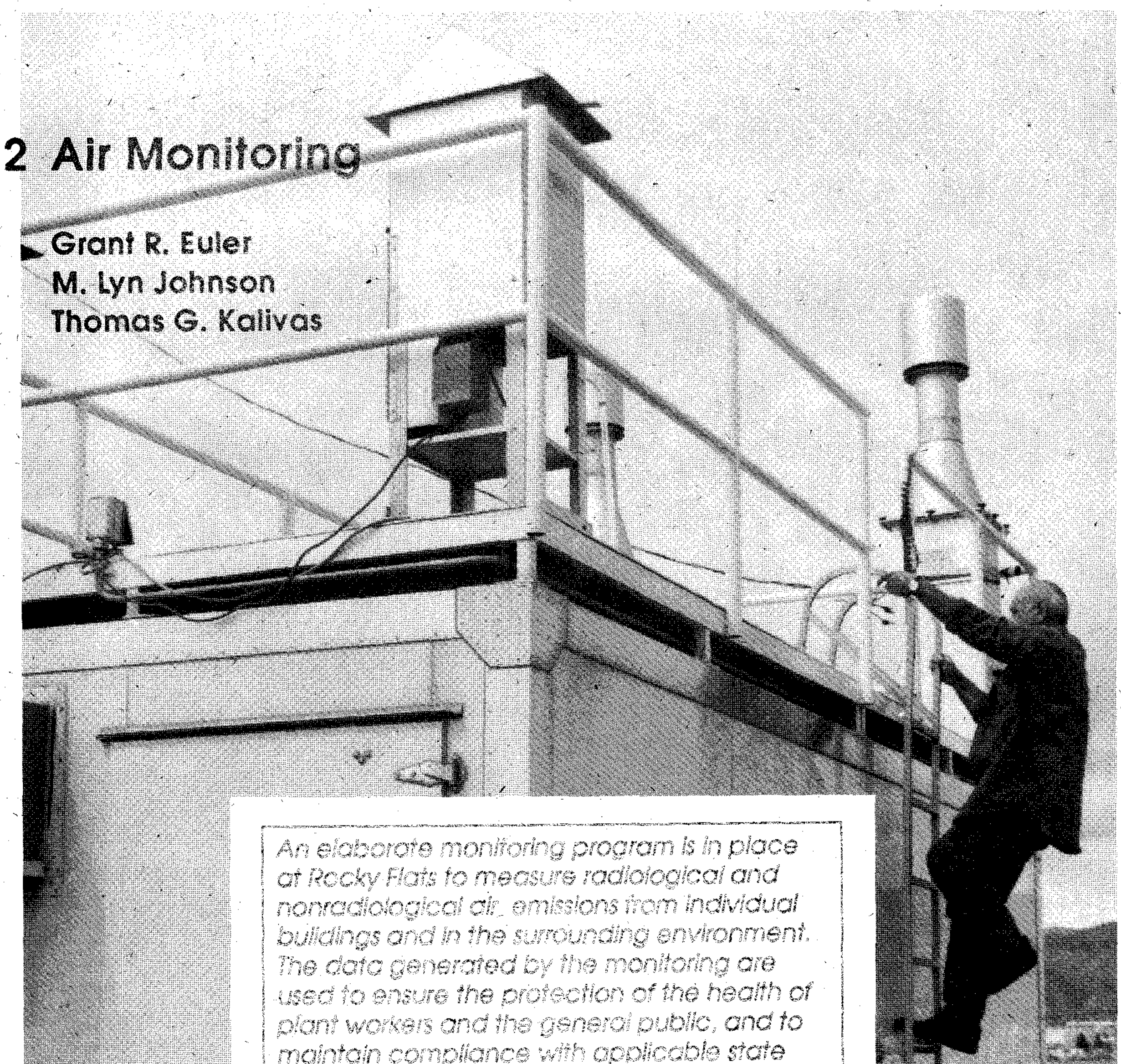
The data show that unstable characteristics (A through C) occur about 11.15 percent of the time, with stable cases (E and F) occurring about 42.63 percent. The D stability class large percentage (46.2) is partially attributed to the average wind speed correction factor mentioned above. Frequency distributions of wind speed and direction for each stability class are presented in Appendix A.

Table 3.1-3
Percent Occurrence of Winds by Stability Class

Stability Class	Percent Occurrence
A	3.30
B	2.42
C	5.43
D	46.20
E	36.6
F	6.03

3.2 Air Monitoring

Grant R. Euler
M. Lyn Johnson
Thomas G. Kalivas



An elaborate monitoring program is in place at Rocky Flats to measure radiological and nonradiological air emissions from individual buildings and in the surrounding environment. The data generated by the monitoring are used to ensure the protection of the health of plant workers and the general public, and to maintain compliance with applicable state and federal air quality regulations. This section provides the results of monitoring from effluent air, and from radioactive and nonradioactive ambient air.

EFFLUENT AIR MONITORING

Overview

For immediate detection of abnormal conditions, RFP building ventilation systems that service areas containing plutonium are equipped with Selective Alpha Air Monitors (SAAMs). SAAMs are sensitive to specific alpha particle energies and are set to detect plutonium -239 and -240. These detectors are subjected to daily operational checks, monthly performance testing and calibration for airflow, and an annual radioactive source calibration to maintain sensitivity and reliability. Monitors alarm automatically if out-of-tolerance conditions are experienced. No such condition occurred during 1991.

At regular intervals, particulate material samples from a continuous sampling system are removed from each exhaust system and radiometrically analyzed for long-lived alpha emitters. The concentration of long-lived alpha emitters is indicative of effluent quality and overall performance of the HEPA filtration system. If the total long-lived alpha concentration for an effluent sample exceeds the RFP actions value of 0.020×10^{-12} microcuries per milliliter (µCi/ml) (7.4×10^{-4} Becquerels per cubic meter [Bq/m^3]), a follow-up investigation is conducted to determine the cause and to evaluate the need for corrective action. The action guide value is equal to the most restrictive offsite DCG for plutonium activity in air. (See Appendix B for guide explanations.)

At the end of each month, individual samples from each exhaust system are composited into larger samples by location. An aliquot of each dissolved composite sample is analyzed for beryllium particulate materials. The remainder of the dissolved sample is subjected to radiochemical separation and alpha spectral analysis, which quantifies specific alpha-emitting radionuclides. Analyses for uranium isotopes are conducted for each composite sample.

Forty-one of the ventilation exhaust systems are located in buildings where plutonium processing is conducted. Particulate material samples from these exhaust systems are analyzed for specific isotopes of plutonium and americium. Typically, americium contributes only a small fraction of the total alpha activity release from RFP.

Processes that are ventilated from several exhaust systems potentially exhibit trace quantities of tritium contamination. Bubble-type samplers are used to collect samples three times each week from the monitored locations. Tritium concentrations in the sample are measured using a liquid scintillation photospectrometer.

Results

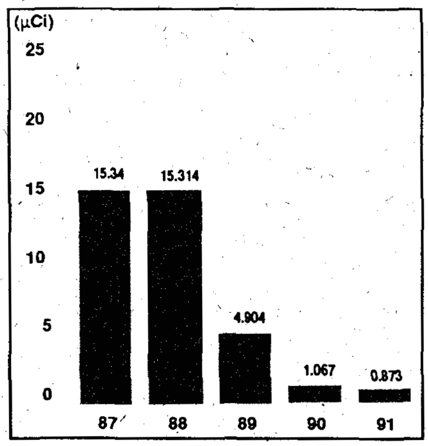


Figure 3.2-1. Plutonium-239, -240

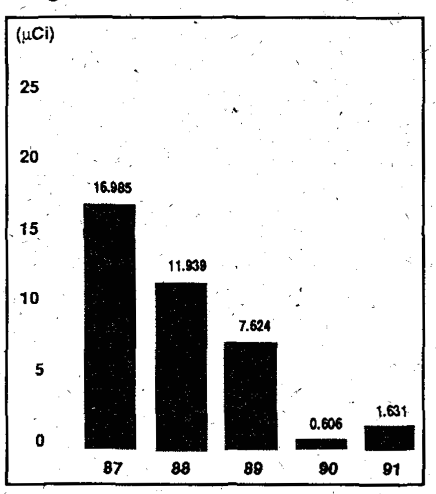


Figure 3.2-2. Uranium-233, -234, -238

Projected doses to the public from radionuclide emissions were within the NESHAP limits of 10 mrem/year EDE. Section 6, "Radiation Dose Assessment," includes a discussion on radiation dose estimates from air emissions.

Plutonium and Uranium. During 1991, total quantities of plutonium and uranium discharged to the atmosphere from RFP processing and support buildings were 0.873 μCi (3.23 x 10^4 Bq) and 1.631 μCi (6.035 x 10^4 Bq), respectively (Tables 3.2-1 and 3.2-2). These values were corrected for background radiation. Annual plutonium-239, -240 and uranium-233, -234,-238 emissions for the 1987-1991 period are given in Figures 3.2-1 and 3.2-2, respectively.

In September 1989, RFP's primary plutonium recovery facility operations were suspended. Operations for the remainder of the plant were suspended following the December 1989 plant inventory; these operations did not resume in 1991. Consequently, overall decreases in radionuclide emissions during 1991 are a reflection of reduced production activities.

Table 3.2-1
Plutonium in Effluent Air

		Plutonium-238		Plutonium-239,-240	
Month	Number of Analyses	Total Discharge (μCi)	C maximum[a] ($x 10^{-12}$ μCi/ml)	Total Discharge (μCi)	C maximum[a] ($x 10^{-12}$ μCi/ml)
January	45	-0.001 ± 0.002	0.0000 ± 0.00000	0.030 ± 0.007	0.00005 ± 0.00001
February	39	0.001 ± 0.001	0.0000 ± 0.00000	0.017 ± 0.007	0.00002 ± 0.00001
March	45	0.002 ± 0.003	0.0000 ± 0.00000	0.018 ± 0.007	0.00001 ± 0.00000
April	45	0.001 ± 0.002	0.0000 ± 0.00000	0.029 ± 0.008	0.00001 ± 0.00000
May	45	0.010 ± 0.004	0.0001 ± 0.00000	0.220 ± 0.035	0.00030 ± 0.00006
June	45	0.001 ± 0.002	0.0000 ± 0.00000	0.036 ± 0.007	0.00001 ± 0.00000
July	45	-0.002 ± 0.002	0.0000 ± 0.00000	0.097 ± 0.016	0.00009 ± 0.00002
August	45	0.001 ± 0.002	0.0000 ± 0.00000	0.039 ± 0.008	0.00003 ± 0.00001
September	43	0.004 ± 0.003	0.0000 ± 0.00000	0.027 ± 0.008	0.00002 ± 0.00001
October	45	0.007 ± 0.006	0.0000 ± 0.00000	0.094 ± 0.022	0.00003 ± 0.00001
November	45	0.008 ± 0.006	0.0000 ± 0.00000	0.022 ± 0.008	0.00007 ± 0.00002
December	45	0.000 ± 0.003	0.0000 ± 0.00000	0.215 ± 0.035	0.00006 ± 0.00001
Overall	532	0.030[b,c] ± 0.036	0.0001 ± 0.00000	0.843[b,c] ± 0.167	0.00030 ± 0.00006

a. Maximum sample concentration.
b. Minor discrepancies in total discharge values result from rounding errors in calculations.
c. One or more values contributing to this total are based on best estimates of release activities because sample analytical results that met all quality assurance criteria were unavailable.

Table 3.2-2
Uranium in Effluent Air

		Uranium-233, -234		Uranium-238	
Month	Number of Analyses	Total Discharge (μCi)	C maximum[a] ($x 10^{-12}$ μCi/ml)	Total Discharge (μCi)	C maximum[a] ($x 10^{-12}$ μCi/ml)
January	53	0.003 ± 0.013	0.0001 ± 0.0001	0.020 ± 0.013	0.0002 ± 0.0001
February	47	0.004 ± 0.013	0.0001 ± 0.0000	0.001 ± 0.011	0.0001 ± 0.0001
March	53	0.026 ± 0.021	0.0001 ± 0.0001	0.033 ± 0.012	0.0001 ± 0.0000
April	53	0.036 ± 0.013	0.0001 ± 0.0001	0.039 ± 0.012	0.0002 ± 0.0000
May	53	0.143 ± 0.029	0.0001 ± 0.0001	0.163 ± 0.030	0.0001 ± 0.0001
June	53	0.127 ± 0.023	0.0001 ± 0.0001	0.147 ± 0.021	0.0003 ± 0.0001
July	53	0.080 ± 0.018	0.0001 ± 0.0001	0.119 ± 0.018	0.0005 ± 0.0001
August	53	0.032 ± 0.019	0.0001 ± 0.0001	0.076 ± 0.019	0.0002 ± 0.0002
September	51	0.041 ± 0.019	0.0001 ± 0.0001	0.063 ± 0.020	0.0001 ± 0.0001
October	53	0.079 ± 0.031	0.0001 ± 0.0001	0.173 ± 0.034	0.0002 ± 0.0001
November	53	0.035 ± 0.021	0.0001 ± 0.0001	0.097 ± 0.026	0.0002 ± 0.0001
December	53	0.024 ± 0.014	0.0001 ± 0.0000	0.070 ± 0.019	0.0002 ± 0.0001
Overall	631	0.629[b,c] ± 0.233	0.0001 ± 0.0001	1.002[b,c] ± 0.235	0.0005 ± 0.0002

a. Maximum sample concentration.
b. Minor discrepancies in total discharge values result from rounding errors in calculations.
c. One or more values contributing to this total are based on best estimates of release activities because sample analytical results that met all quality assurance criteria were unavailable.

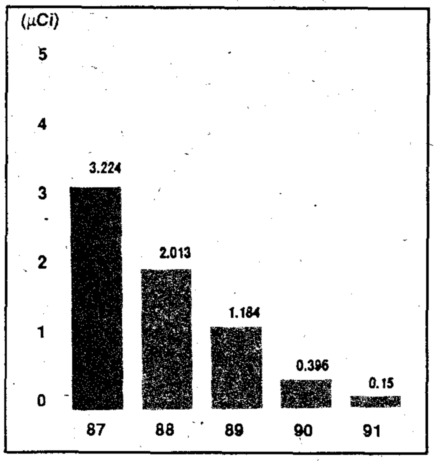


Figure 3.2-3. Americium-241

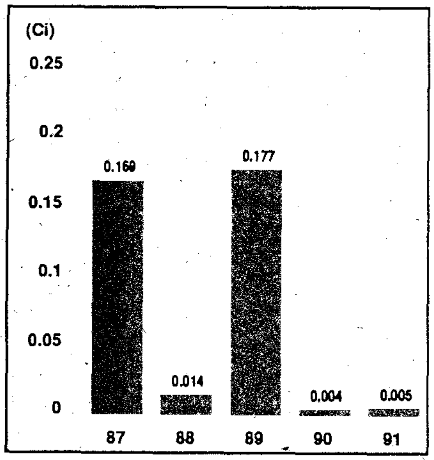


Figure 3.2-4. Tritium

Values reported for total quantities of plutonium and uranium discharged in 1991 vary from the monthly environmental monitoring reports because of rounding in calculations and that the annual report includes plutonium-238, -239, and -240. Plutonium-238 represents 3.4 percent of the total plutonium discharged in 1991.

Americium. Total americium discharged in 1991 was 0.150 µCi (0.422 x 10^4 Bq) (Table 3.2-3). Maximum concentration was 0.0006 x 10^{-12} µCi/ml, observed in samples taken in January. Americium values were corrected for background radiation. Annual americium emissions for the period 1987 - 1991 are shown in Figure 3.2-3.

Tritium. Total tritium discharged in 1991 from ventilation systems in which tritium is routinely measured was 0.0048 Ci (1.77 x 10^8 Bq) (Table 3.2-4). The maximum tritium concentration of 94 x 10^{-12} µCi/ml (3.48 Bq/m^3) was observed during June from routine operations in a plutonium production building. Each month is divided into a series of individual sampling periods. The sum of discharge for these sampling periods is the total tritium discharge for the month. Tritium values include a small, unquantified contribution attributed to natural background (i.e., non-plant) sources. Annual tritium emissions for the period 1987-1991 are given in Figure 3.2-4.

Beryllium. The total quantity of beryllium discharged from ventilation exhaust systems was 7.086 g and the maximum concentration was 0.0018 µg/m^3 observed in April. The beryllium stationary-source emission standard is 10 g over a 24-hour period. Table 3.2-5 presents the beryllium airborne effluent data for 1991. RFP stopped using analytical blanks in laboratory analysis to correct sample beryllium concentrations in September 1989. Consequently, reported beryllium values measure both background and actual emission levels.

The total quantity of beryllium discharged in 1991 varies from quantities reported in the monthly environmental monitoring reports because the annual report

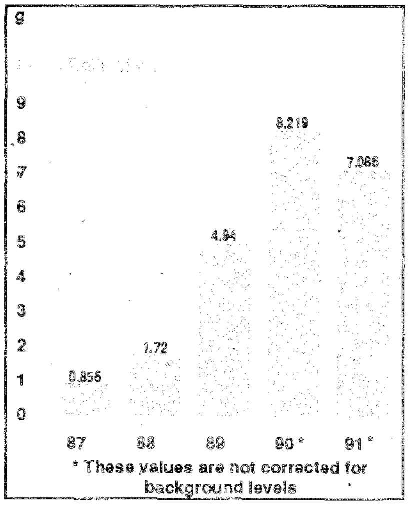


Figure 3.2-5. Beryllium

includes values for all 49 exhaust systems, whereas the monthly reports give discharges for six exhaust systems on buildings where beryllium is processed. Beryllium discharges are monitored monthly at the remaining 43 locations but are only given in monthly reports if they exceed a screening level of 0.1 g. Annual beryllium emissions for the period 1987-1990 are shown in Figure 3.2-5. Total annual emissions for 1987 and 1988 differ from values reported in the annual site environmental reports for 1987 and 1988. Discharges from all 49 exhaust systems are represented in Figure 3.2-5, whereas values reported in the 1987 and 1988 reports were only for the six exhaust systems.

Table 3.2-3
Americium in Effluent Air

Americium-241

Month	Number of Analyses	Total Discharge (μCi)			C maximum[a] ($\times 10^{-12}$ μCi/ml)		
January	45	0.0075	±	0.0030	0.0006	±	0.0001
February	39	0.0076	±	0.0032	0.0001	±	0.0001
March	45	0.0008	±	0.0039	0.0001	±	0.0000
April	45	0.0046	±	0.0044	0.0000	±	0.0000
May	45	0.0070	±	0.0100	0.0002	±	0.0001
June	45	0.0093	±	0.0032	0.0000	±	0.0000
July	45	0.0221	±	0.0076	0.0002	±	0.0000
August	45	0.0092	±	0.0054	0.0001	±	0.0000
September	53	0.0080	±	0.0036	0.0000	±	0.0000
October	45	0.0307	±	0.0068	0.0000	±	0.0000
November	45	0.0126	±	0.0070	0.0001	±	0.0000
December	45	0.0310	±	0.0102	0.0001	±	0.0000
Overall	*532*	*0.150[b,c]*	*±*	*0.068*	*0.0006*	*±*	*0.0001*

a. Maximum sample concentration.
b. Minor discrepancies in total discharge values result from rounding errors in calculations.
c. One or more values contributing to this total are based on best estimates of release activities because sample analytical results that met all quality assurance criteria were unavailable.

Table 3.2-4
Tritium in Effluent Air

Month	Number of Analyses	Tritium: Total Discharge (Ci)	Tritium: C maximum[a] ($x 10^{-12}$ µCi/ml)
January	33	0.0001	19 ± 8
February	31	0.0002	30 ± 18
March	42	0.0002	27 ± 9
April	55	0.0004	40 ± 17
May	58	0.0001	21 ± 6
June	42	0.0005	94 ± 55
July	42	0.0009	68 ± 10
August	42	0.0005	61 ± 13
September	49	0.0003	48 ± 15
October	76	0.0007	50 ± 8
November	72	0.0005	92 ± 17
December	72	0.0008	35 ± 16
Overall	614	0.0048[b]	94 ± 55

a. Maximum sample concentration.

b. Minor discrepancies in total discharge values result from rounding errors in calculations.

Table 3.2-5
Beryllium in Effluent Air

Month	Number of Analyses	Beryllium[a,b]: Total Discharge[c] (g)	Beryllium[a,b]: C maximum[d] (µg/m^3)
January	53	0.5474	0.0006
February	47	0.5497	0.0008
March	53	0.4777	0.0004
April	53	0.5768	0.0018
May	53	0.9644	0.0009
June	53	0.8837	0.0010
July	53	0.6133	0.0014
August	53	0.3260	0.0005
September	51	0.4015	0.0010
October	53	0.4598	0.0011
November	53	0.8125	0.0008
December	53	0.5725	0.0006
Overall	631	7.0853	0.0018

a. The beryllium stationary-source is no more than 10 grams of beryllium over a 24-hour period under the provisions of subpart C of 40 CFR 61.32(a).

b. Beginning in June 1989, concentrations and emission values were not corrected for background contribution.

c. These values are not significantly different from the background associated with the analysis.

d. Maximum sample concentration.

NONRADIOACTIVE AMBIENT AIR MONITORING

Nonradioactive ambient air monitoring was conducted in 1991 for TSPs and respirable particulates (less than or equal to [≤] 10 micrometers [μm]) in diameter. Ambient particulates are regulated by EPA and CDH under CAA Amendments of 1970 and 1977, as defined by the National Ambient Air Quality Standards (NAAQS) and Colorado Air Quality Control Commission Ambient Air Standards. Regulation is based on regional rather than site-specific air quality parameters. Formerly, EPA particulate standards (NAAQS) were based on TSP, a measure of total particulate recovery, regardless of particulate size. The present EPA standard, referred to as Particulate Matter-10 or PM-10, is based on respirable particulates, those particles ≤ 10 μm in diameter. Final EPA respirable particulate standards were issued on July 1, 1987 (EPA87a), and reference methods were issued on October 6 and December 1, 1987. PM-10 samplers at RFP were procured to meet EPA design specifications.

Ambient air monitoring at RFP provides baseline information on particulate levels. Table 3.2-6 identifies sampling equipment used for measuring particulates. RFP monitors ambient air with both TSP and PM-10 samplers. CDH has requested concurrent TSP sampling until changes have been made in state regulations to reflect PM-10 changes in federal regulations. TSP and PM-10 samplers are collocated near the east entrance to RFP. This location is unobscured by structures, near a traffic zone, and generally downwind from plant buildings. Samplers are operated on an EPA sampling schedule of 1 day per every 6th day. TSP is measured by the EPA-referenced, high-volume air sampling method.

Results

Particulate data are shown in Table 3.2-7; current (PM-10) and former (TSP NAAQS) standards are given in Appendix B. The highest TSP value recorded in 1991 (24-hour sample) was 82.3 micrograms per cubic meter (μg/m^3) (32 percent of the former TSP 24-hour primary standard), and the annual geometric mean value was 39.8 μg/m^3 (53 percent of former TSP primary annual

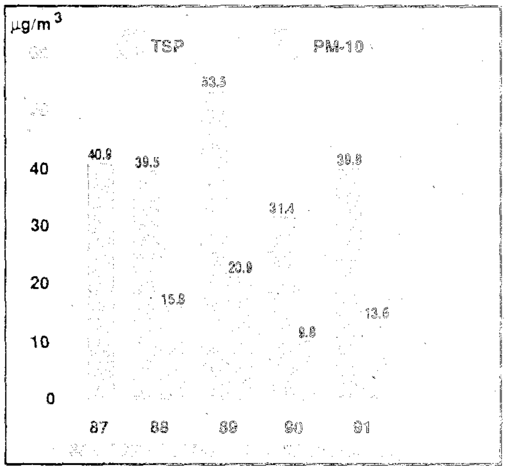


Figure 3.2-6. TSP and PM-10

geometric mean standard). The observed 24-hour maximum for the PM-10 sampler was 26.3 μg/m^3 (18 percent of the primary 24-hour standard) and the annual arithmetic mean was 13.6 μg/m^3 (27 percent of the primary annual arithmetic mean standard). Mean annual concentrations of particulates for onsite ambient TSP samplers (1987-1991) and PM-10 samplers (1987-1991) are shown in Figure 3.2-6.

Table 3.2-6
Ambient Air Monitoring Detection Methods

Parameter	Detection Methods
Particulate Matter less than 10 micrometers in diameter (PM-10)	Wedding PM-10 Sampler 24-Hour sampling (6th-day scheduling)
Total Suspended Particulates (TSP)	Reference Method (Hi Volume) 24-Hour sampling (6th-day scheduling)

Table 3.2-7
Ambient Air Quality Data for Nonradioactive Particulates

Total Suspended Particulates

	Total No. of Samples	Annual Geometric Mean (μg/m^3)	Standard Deviation (μg/m^3)	Observed 24-hr Max. (μg/m^3)	Second Highest Max. (μg/m^3)	Lowest Observed Value (μg/m^3)
Primary Ambient Air TSP Particulate Sampler; Reporting Unit	36.0[a]	39.8	18.4	82.3	79.2	17.3
Collocated Duplicate TSP Sampler	52.0[a]	36.8	15.2	74.9	73.6	12.8

Respirable Particulates (PM-10)

	Total No. of Samples	Annual Arithmetic Mean (μg/m^3)	Observed 24-hr Max. (μg/m^3)	Second Highest Max. (μg/m^3)
Primary Ambient Air PM-10 Sampler	49.0	13.6	24.0	22.6
Collocated Duplicate PM-10 Sampler	49.0	13.5	26.3	22.2

a. The difference in number of samples from primary and collocated duplicate samplers is because of motor failure during a time of lower response technician support.

RADIOACTIVE AMBIENT AIR MONITORING

Overview

Ambient air samplers monitor airborne dispersion of radioactive materials from RFP into the surrounding environment. Samplers are designated in three categories by their proximity to the main facilities area. Twenty-three onsite samplers are located within RFP, concentrated near the main facilities area (Figure 3.2-7). Fourteen perimeter samplers border RFP along major highways on the north (Highway 128), east (Indiana Street), south (Highway 72), and west (Highway 93) (Figure 3.2-7). Fourteen community samplers are located in metropolitan areas adjacent to RFP (Figure 3.2-8). Samplers operate continuously at a volumetric flow rate of approximately 12 liters per second (l/s) (25 cubic feet per minute [ft^3/min]), collecting air particulates on 20- by 25-centimeter (8- by 10-inch) fiberglass filters. Manufacturer's test specifications rate this filter media to be 99.97 percent efficient for relevant particle sizes under conditions typically encountered in routine ambient air sampling (SC82).

Filters were collected biweekly from all samplers, composited by location, and analyzed monthly for plutonium.

Results

Plutonium concentrations for onsite samplers are given in Table 3.2-8. Plutonium concentrations for perimeter and community samplers are given in Table 3.2-9. Overall mean plutonium concentration for onsite samplers was 0.073 x 10^{-15} µCi/ml (2.7 x 10^{-6} Bq/m^3), 0.36 percent of the offsite DCG for plutonium in air (Appendix B). Overall mean plutonium concentration for perimeter samplers was 0.001 x 10^{-15} µCi/ml (3.7 x 10^{-8} Bq/m^3). Overall mean plutonium concentration for community samplers was 0.001 x 10^{-15} µCi/ml (3.7 x 10^{-8} Bq/m^3). These values are both 0.005 percent of the offsite DCG.

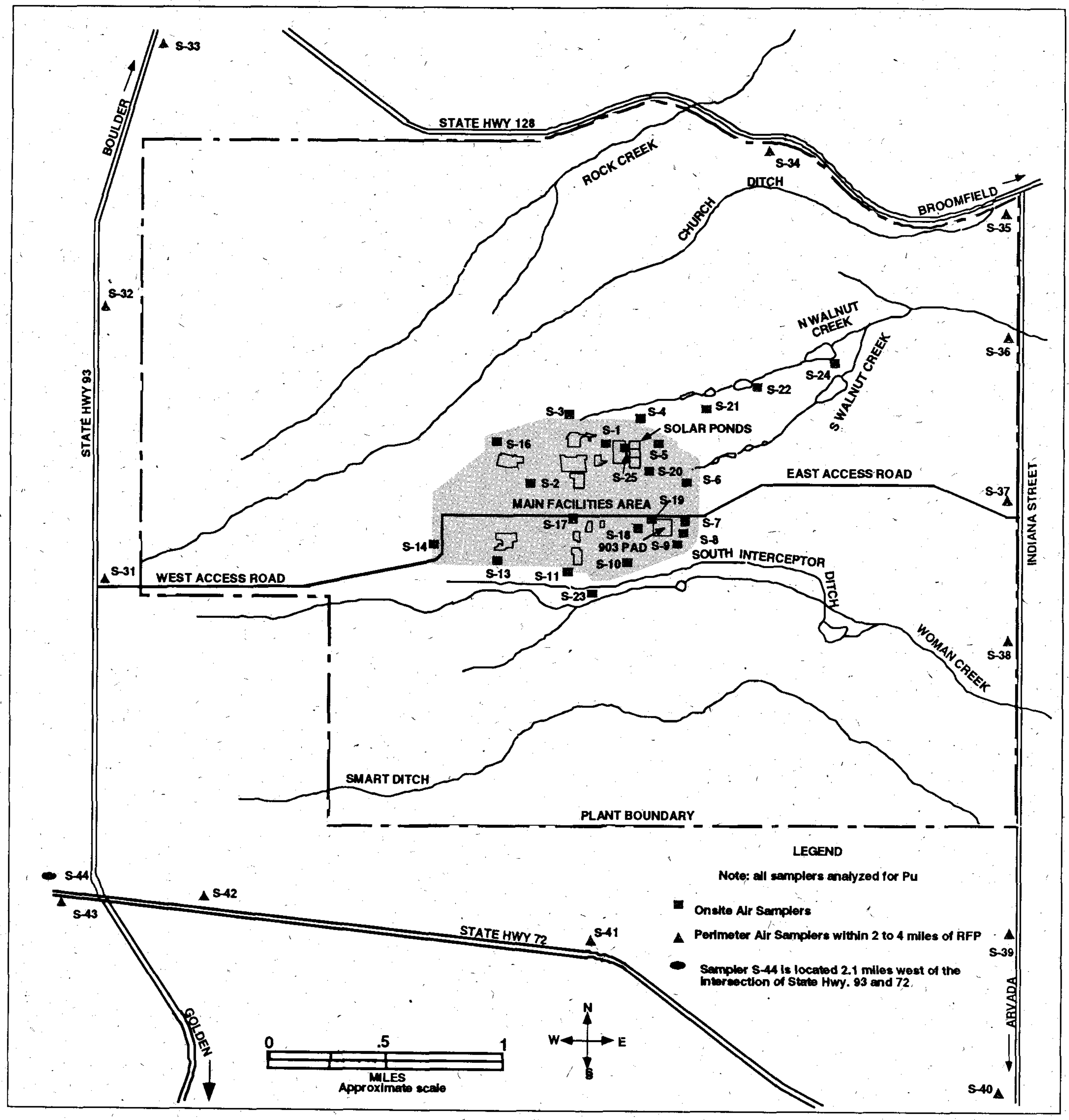


Figure 3.2-7. Onsite and Perimeter Ambient Air Samplers

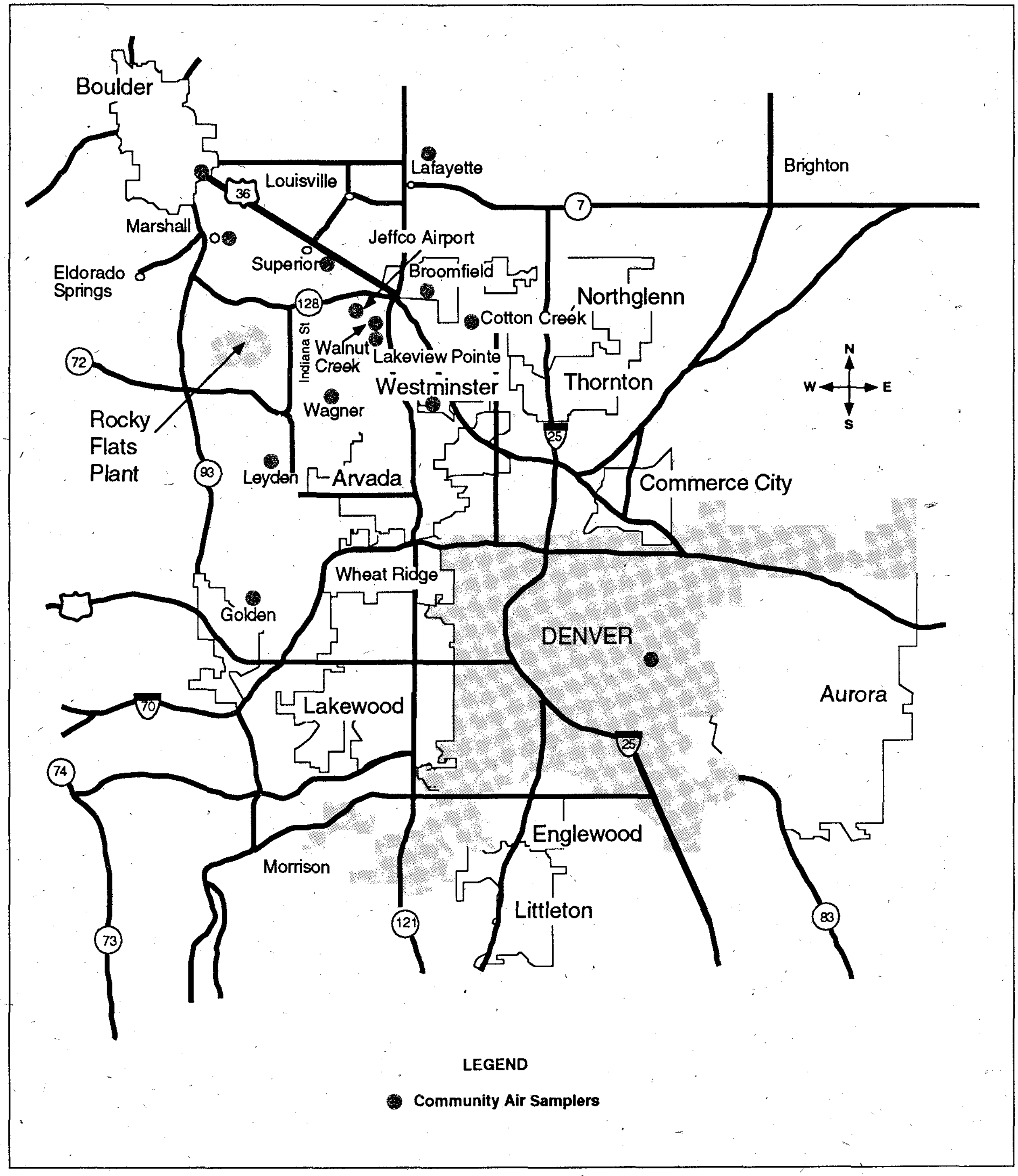


Figure 3.2-8. Community Ambient Air Samplers

Table 3.2-8

Onsite Ambient Air Sampler Plutonium Concentrations[a,b]

Station	Number of Samples	Concentration (x 10^{-15} µCi/ml)[c] C minimum	C maximum	C mean	Standard Deviation (C standard)	Percent of DCG[d] (C mean)
S-1	7	0.209	3.197	1.152	1.085	5.758
S-2	11	0.001	0.073	0.012	0.021	0.058
S-3	6	-0.002	0.006	0.002	0.003	0.008
S-4	11	0.001	0.015	0.007	0.005	0.035
S-5	12	0.003	0.106	0.045	0.033	0.223
S-6	12	0.010	0.362	0.125	0.114	0.623
S-7	12	0.012	0.107	0.050	0.033	0.252
S-8	10	0.010	0.169	0.082	0.054	0.412
S-9	11	0.002	0.461	0.082	0.134	0.410
S-10	11	0.001	0.093	0.014	0.027	0.070
S-11	9	0.000	0.015	0.005	0.004	0.023
S-12[e]	8	0.002	0.010	0.006	0.003	0.029
S-13	10	-0.002	0.028	0.006	0.009	0.028
S-14	8	-0.004	0.006	0.001	0.003	0.004
S-15*[e]	8	0.000	0.012	0.003	0.004	0.016
S-16	11	0.000	0.028	0.005	0.008	0.027
S-17	11	0.005	0.050	0.013	0.013	0.066
S-18*	11	0.003	0.220	0.038	0.062	0.190
S-19	11	0.002	0.022	0.013	0.005	0.063
S-20	12	0.007	0.461	0.052	0.129	0.261
S-21	12	0.002	0.023	0.009	0.007	0.046
S-22	11	-0.001	0.011	0.005	0.004	0.023
S-23	12	-0.001	0.011	0.003	0.004	0.017
S-24	11	-0.001	0.132	0.022	0.042	0.111
S-25	11	0.001	0.708	0.162	0.211	0.808
Overall	248	-0.004	3.197	0.073	0.075	0.365

a. Data provided in this table are based on various periods of sampling. *The locations not marked with an asterisk are calculated on a 12-month basis. The other locations are calculated using less than 12 months of data due to mechanical malfunctions, incomplete laboratory analyses, or the installation of a new sampler (S-25) that has not been in service for a complete year.

b. Isotope-specific analyses were reported only for locations S-5 through S-9 before 1990 (see Figure 3.2-7). These five samplers are the only onsite locations included in the 5-year trending portion of this report.

c. Concentrations reflect monthly composites of biweekly station concentrations; C minimum = minimum composited concentration; C maximum = maximum composited concentration; C mean = mean composited concentration.

d. The DOE Derived Concentration Guide (DCG) for inhalation of class W plutonium by members of the public is 20 x 10^{-15} µCi/ml (Appendix B). Protection standards for members of the public are applicable for offsite locations. All locations in this table are on RFP property. DCGs for the public are presented here for comparison purposes only.

e. This station has been removed.

Table 3.2-9

Perimeter Ambient Air Sampler Plutonium Concentrations[a]

Station	Number of Samples	Concentration ($\times 10^{-15}$ µCi/ml)[b] C minimum	C maximum	C mean	Standard Deviation (C standard)	Percent of DCG[c] (C mean)
S-31*	11	-0.003	0.007	0.002	0.003	0.009
S-32	12	-0.003	0.006	0.001	0.003	0.004
S-33	11	-0.002	0.007	0.001	0.003	0.006
S-34	10	-0.002	0.002	0.001	0.001	0.003
S-35	11	-0.003	0.005	0.001	0.002	0.004
S-36	12	-0.001	0.004	0.001	0.002	0.004
S-37	11	0.000	0.018	0.004	0.005	0.020
S-38	11	-0.002	0.006	0.001	0.003	0.007
S-39	11	-0.002	0.007	0.002	0.003	0.009
S-40*	12	0.000	0.005	0.002	0.002	0.009
S-41	12	-0.002	0.003	0.000	0.001	0.002
S-42	9	-0.001	0.002	0.001	0.001	0.003
S-43	12	-0.001	0.003	0.001	0.001	0.006
S-44	12	-0.001	0.008	0.002	0.003	0.010
Overall	157	-0.003	0.018	0.001	0.002	0.007

Community Ambient Air Sampler Plutonium Concentrations[a]

Station	Number of Samples	Concentration ($\times 10^{-15}$ µCi/ml)[b] C minimum	C maximum	C mean	Standard Deviation (C standard)	Percent of DCG[c] (C mean)
S-51	10	-0.003	0.003	0.001	0.002	0.004
S-52	12	-0.001	0.005	0.002	0.002	0.010
S-53	12	-0.002	0.022	0.002	0.007	0.011
S-54	12	-0.003	0.004	0.000	0.002	0.000
S-55	7	0.000	0.003	0.001	0.001	0.007
S-56	12	-0.002	0.004	0.001	0.002	0.005
S-57	7	0.001	0.007	0.002	0.002	0.011
S-58*	12	-0.002	0.019	0.003	0.006	0.014
S-59	12	-0.002	0.004	0.001	0.002	0.003
S-60	10	-0.002	0.014	0.003	0.005	0.013
S-62	12	-0.003	0.004	0.001	0.002	0.005
S-68	11	-0.002	0.008	0.002	0.003	0.010
S-73	12	-0.005	0.002	0.000	0.002	0.002
Overall	141	-0.005	0.022	0.001	0.003	0.007

a. Data provided in this table are based on an 12-month period except those marked with an asterisk.
b. Concentrations reflect monthly composites of biweekly station concentrations; C minimum = minimum composited concentration; C maximum = maximum composited concentration; C mean = mean composited concentration.
c. The DOE Derived Concentration Guide (DCG) for inhalation of class W plutonium by members of the public is 20×10^{-15} µCi/ml (Appendix B). Protection standards for members of the public are applicable for offsite locations and are based on calculated radiation dose.

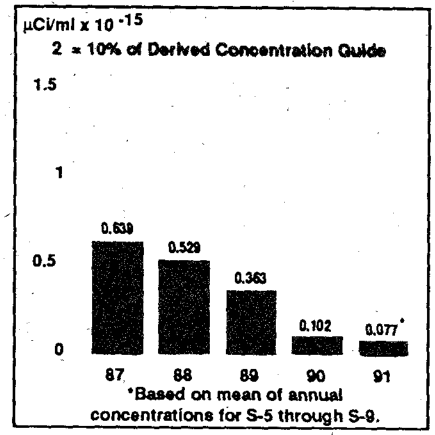


Figure 3.2-9. Plutonium-239, -240 (Onsite Samplers)

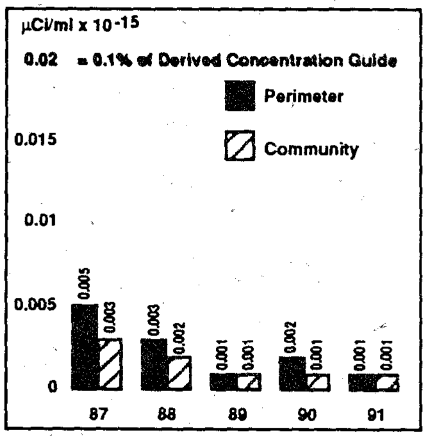


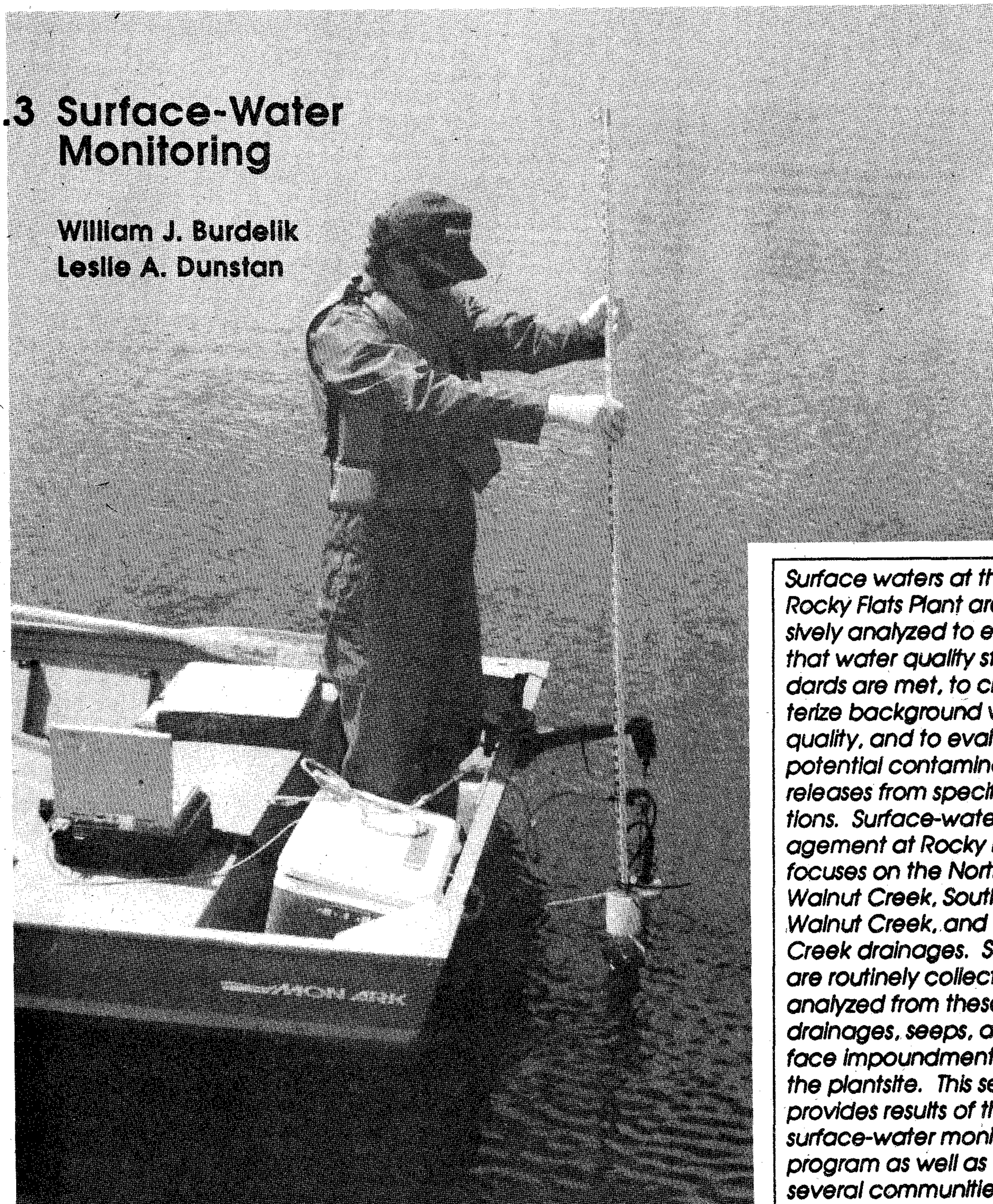
Figure 3.2-10. Plutonium-239, -240 (Perimeter and Community Samplers)

Mean annual concentrations of plutonium for 1987-1991 are shown in Figure 3.2-9 (onsite samplers) and Figure 3.2-10 (perimeter and community samplers). The onsite data are based on the mean of the annual concentrations from five locations, S-5 through S-9, which represent the areas where the highest concentrations would most likely be observed. Isotope-specific analyses were not reported for other onsite locations until 1990. The perimeter and community data points are the annual averages of 14 locations within each of these areas.

3. Environmental Monitoring Programs

3.3 Surface-Water Monitoring

William J. Burdelik
Leslie A. Dunstan



Surface waters at the Rocky Flats Plant are extensively analyzed to ensure that water quality standards are met, to characterize background water quality, and to evaluate potential contaminant releases from specific locations. Surface-water management at Rocky Flats focuses on the North Walnut Creek, South Walnut Creek, and Woman Creek drainages. Samples are routinely collected and analyzed from these drainages, seeps, and surface impoundments within the plantsite. This section provides results of the surface-water monitoring program as well as that of several communities that surround the plantsite.

DRAINAGE SYSTEMS

North Walnut Creek

North Walnut Creek receives surface water runoff and some seepage water from the northern portion of the main facilities area and from the adjacent grounds associated with the drainage. The drainage area encompasses approximately 371 acres (Figure 3.3-1). The length of the North Walnut Creek reach from the West Interceptor Ditch to the outfall of Pond A-4 is approximately 10,500 feet. Ponds A-1 and A-2 are isolated from Walnut Creek at the A-1 bypass. The gate valves at the A-1 bypass have the capabilities to divert the North Walnut Creek stream flow by way of an underground pipeline to Ponds A-3 or A-4. Ponds A-1 and A-2 are maintained for emergency spill control for the northern portion of the main facility. Under routine circumstances, the water comprising Pond A-2 is direct precipitation, minimal runoff, or water transferred from Ponds A-1, B-1, and B-2. Pond A-2 volume is maintained by spray evaporation; fog nozzles direct the spray over the surface of the ponds. Pond A-3 on North Walnut Creek is used to impound the surface runoff for water quality analysis prior to NPDES discharge to Pond A-4 and subsequent release offsite to the Broomfield Diversion Ditch. Pond A-4 is located downstream of Pond A-3 on North Walnut Creek and provides the capability for additional water quality monitoring, additional detention capacity during storm or flood conditions, and water treatment if required. The volumetric capacity of Pond A-1 is 1.40 million gallons; Pond A-2, 6.00 million gallons; Pond A-3, 12.37 million gallons; and Pond A-4, 32.50 million gallons.

South Walnut Creek

South Walnut Creek receives surface-water runoff and some seepage water from the central portion of the main facilities area and from the adjacent grounds associated with the drainage. The drainage area associated with a portion of South Walnut Creek is approximately 347 acres (Figure 3.3-1). The length of the South Walnut Creek reach from Building 131 at First Street to Pond B-5 is approximately 9,625 feet. Ponds B-1 and B-2 are isolated from South Walnut Creek at the B-1 bypass. Ponds B-1 and B-2 are maintained for emergency spill control for the central portion of the main facility. In the event of a spill emergency, the gate valves at the B-1 bypass have the capability of diverting South Walnut Creek flows to Pond B-1, and succeeding overflow to Pond B-2. The Waste Water Treatment Plant (WWTP) (also known as the Sewage Treatment Plant) has bypass capabilities to Ponds B-1 and B-2 in the event of an upset or emergency. Under normal operation, the B-1 bypass conveys surface runoff water by an underground pipeline from the bypass to Pond B-4 and subsequently to Pond B-5. During major precipitation events, storm water may be diverted prior to the B-1 bypass at the Central Avenue splitter box. These high flows are diverted directly to Pond B-5.

The WWTP discharges treated sanitary effluent to Pond B-3. Pond B-3 is impounded during evening hours and is released to Pond B-4 during daylight hours on a daily basis. Pond B-4 is a controlled flow-through pond, and all flow is conveyed to Pond B-5. Pond B-5 is the terminal pond of the B series on South Walnut Creek. In the past, water was discharged from Pond B-5 offsite; under prevailing operations, water quality analysis and sampling is conducted on Pond B-5 prior to transfer to Pond A-4, for final discharge offsite. The volumetric capacity of Pond B-1 is 0.50 million gallons; Pond B-2, 1.50 million gallons; Pond B-3, 0.57 million gallons; Pond B-4, 0.18 million gallons; and Pond B-5, 24.19 million gallons.

Woman Creek

Woman Creek flows south of the main plant facility. The drainage area associated with Woman Creek is approximately 1,400 acres (Figure 3.3-1). The length of Woman Creek from the West Gate to Indiana Street is approximately 22,000 feet. The three sources of flow to the Woman Creek are precipitation and surface runoff, seepage from Antelope Springs and lessor seeps, and conveyance flows because of water rights agreements. These flows are from Kinear Ditch, Smart Ditch #1, and/or Smart Ditch #2 into Woman Creek. Woman Creek stream flows through Pond C-1 and is then diverted around Pond C-2 by way of the Woman Creek

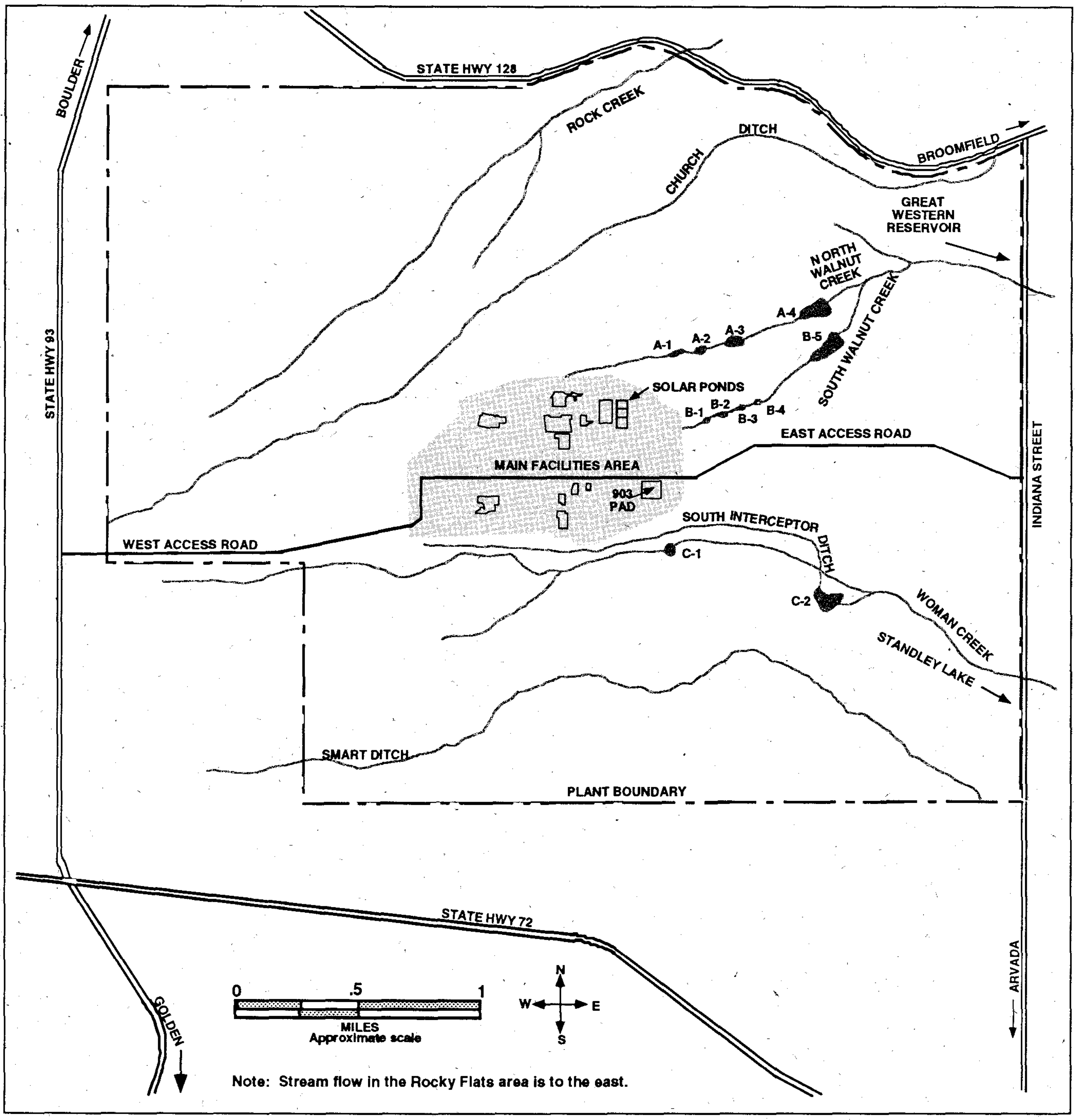


Figure 3.3-1. Holding Ponds and Liquid Effluent Water Courses

Bypass Canal. Woman Creek flows are either diverted into the Mower Diversion Ditch or proceed in Woman Creek to Indiana Street and offsite.

Surface water runoff from the southern portion of RFP is collected by the South Interceptor Ditch and conveyed to Pond C-2. The drainage area associated with the South Interceptor Ditch is approximately 193 acres. The South Interceptor Ditch is approximately 7,700 feet in length. Water is impounded in Pond C-2 and held for quality analysis. Upon approval, water is discharged by pipeline to the Broomfield Diversion Ditch. In the past, water was discharged to Woman Creek and entered Standley Lake. The volumetric capacity of Pond C-1 is 1.70 million gallons and Pond C-2 is 22.60 million gallons.

MONITORING PROGRAMS

Detention Ponds Monitoring

Before discharge from Ponds A-4 and C-2, samples are taken and split for analysis by CDH, EG&G Rocky Flats, Inc., and independent EPA-registered laboratories. Discharges are monitored for parameters listed in Appendix B in compliance with NPDES permit limitations. In addition, water quality is tested to ensure that it meets CWQCC standards for Segment 4 of Big Dry Creek before release. These standards are listed in Appendix B. Water is released with concurrence from CDH. Carbon adsorption and filtration facilities are available if required. Treatment capacity at Pond A-4 and C-2 are 1,400 gallons per minute (gpm) and 750 gpm, respectively.

Samples of all discharges from Ponds A-4 and C-2 are collected by daily composites for weekly analysis of plutonium, uranium, and americium. Tritium, pH, nitrate (as nitrogen), and nonvolatile suspended solids are analyzed daily. Chromium and Whole Effluent Toxicity (WET) samples are analyzed monthly. Monthly chromium and WET samples are also collected on Pond B-5 transfers. Discharges from Pond C-2 and flow from Walnut Creek near its intersection with Indiana Street are sampled in a similar manner. Daily samples from Pond C-2 and Walnut Creek are analyzed for tritium. Daily samples are composited weekly for plutonium, uranium, and americium analysis.

Discharges from Ponds A-4 and B-5 enter Walnut Creek and are diverted around Great Western Reservoir using the Broomfield Diversion Ditch. Discharges from Pond C-2 are pumped through an 8,000-foot pipeline into the Broomfield Diversion Ditch, which eventually discharges into the South Platte River. Monthly flow and discharges for 1991 at Ponds A-4, B-5, C-2, and C-1, and for Walnut Creek at Indiana are given in Table 3.3-1.

Table 3.3-1
Monthly Flow and Discharges for 1991 (gallons)

Month	Walnut Creek at Indiana	Pond A-4	Pond B-5	Pond C-2	Pond C-1
January	898,000	1,052,000	No Discharge	No Discharge	8,949,000
February	13,334,000	11,515,000	No Discharge	No Discharge	9,767,000
March	14,459,000	13,185,000	No Discharge	No Discharge	2,939,000
April	6,699,000	7,159,000	No Discharge	No Discharge	4,461,000
May	20,382,000	14,925,000	No Discharge	No Discharge	8,316,000
June	62,072,000	46,335,000	No Discharge	10,772,000[a]	7,099,000[b]
July	4,667,000	3,916,000	No Discharge	No Discharge	1,528,000
August	9,689,000	7,161,000	No Discharge	No Discharge	3,372,000
September	13,412,000	12,519,000	No Discharge	No Discharge	667,000
October	7,628,000	7,952,000	No Discharge	No Discharge	2,451,000
November	Low Flow[c]	No Discharge	No Discharge	No Discharge	8,857,000
December	26,387,000	27,076,000	No Discharge	No Discharge	5,901,000
Total	179,627,000	152,795,000	No Discharge	10,772,000	57,208,000

a. Discharge is directed via pipeline to Broomfield Diversion Ditch.
b. Volume represents estimate from 25-year storm event; flow measurement equipment could not accurately quantify volume.
c. Flow was observed, but flow measurement equipment could not accurately quantify volume.

Sitewide Monitoring

In addition to monitoring discharges from detention ponds, RFP conducts sitewide surface-water sampling programs to evaluate potential contaminant releases and to characterize baseline water quality. These programs assess trends and changing conditions in surface-water quality, detect extreme values or excursions beyond a limit, assess the relationship between water quality and flow, identify new contaminant sources and releases, and address surface-water sediment interactions.

Routine sitewide monitoring was started in early 1989 to provide surface-water quality and flow information for seeps and drainages in the main facilities area and buffer zone that may be affected by plant operations. The focus of this sampling program was to measure potential contaminants to surface-water from suspected source areas such as designated CERCLA OUs. Results for 1989 are reported in the document titled *Draft 1989 Surface Water and Sediment Geochemical Characterization Report* (EG91d).

The sitewide program includes monthly surface-water sampling at 108 locations and quarterly sediment sampling at approximately 32 locations plantwide. The sitewide program will be modified in 1992 to accommodate remedial investigation data collection and additional characterization needs. This modification will involve a large reduction in the number of monitoring locations and sampling frequency. The sitewide program has provided data for 3 years of monitoring. EG&G Rocky Flats, Inc., is confident that these data are of adequate quality and quantity to meet DOE Order 5400.1 characterization requirements.

Additional sitewide characterization will be accomplished through storm-event monitoring at a network of 13 stream gages located plantwide. Stream gages are equipped with continuously recording stream flow monitors and automatic samplers that are programmed to sample storm-event flows. Since the potential for contaminant transport is greatest during storm events, storm-event monitoring will provide better information for characterization of contaminant fate and transport than does the current sitewide program.

A separate background monitoring program began in 1989 to establish baseline water quality data for waters unaffected by plant operations. These data serve as a comparison to samples from affected areas of RFP to judge the potential impact of contamination from plant activities. Monitoring stations were selected upgradient and sidegradient of the main facilities where no impact from plant activities was presumed. Results are reported in the *Background Geochemical Characterization Report for 1989* (EG90d).

MONITORING RESULTS

Nonradiological Monitoring

The NPDES FFCA between EPA and DOE, finalized in 1991, established an additional monitoring point at the WWTP. Most limitations and monitoring requirements previously applied at outfall 001 are now applied at the WWTP.

Annual average concentrations of chemical and biological constituents measured in surface-water effluent samples collected before the finalization of the FFCA are presented in Table 3.3-2; those collected after the FFCA was finalized are presented in Table 3.3-3. Concentrations are indicative of the overall quality of effluent discharges. Certain discharges must meet NPDES permit monitoring and compliance limitations described in Appendix B.

Radiological Monitoring

Concentrations of plutonium, uranium, americium, and tritium in water samples from the outfalls of Ponds A-4, C-1, C-2, and from Walnut Creek at Indiana Street are presented in Tables 3.3-4 and 3.3-5. Mean plutonium, uranium, americium, and tritium concentrations at all sample locations were less than .27 percent (based on an incomplete data set) of applicable DCGs (Appendix B).

The annual cumulative total amount of plutonium, uranium, and americium discharged to offsite waters during the year was calculated using each individual discharge concentration and flow measurement. Following are the cumulative discharge amounts for 1991.

	Pond A-4	Pond C-2
Pu - Ci (Bq)	1.39×10^{-6} (5.15×10^{4})	5.22×10^{-7} (1.93×10^{4})
U-234 - Ci (Bq)	4.25×10^{-4} (1.58×10^{7})	3.48×10^{-5} (1.29×10^{6})
U-238 - Ci (Bq)	4.23×10^{-4} (1.57×10^{7})	4.10×10^{-5} (1.51×10^{6})
Am - Ci (Bq)	6.13×10^{-6} (2.27×10^{5})	3.18×10^{-7} (1.18×10^{4})

Table 3.3-2

Chemical and Biological Constituents in Surface Water Effluents at NPDES Permit Discharge Locations January through April 1991[a,d,e]

Parameters	Number of Analyses	C minimum[b]	C maximum[b]	C mean[b,c]
Discharge 001 (Pond B-3)				
pH, standard units	89	6.17	8.14	N/A
Nitrate as N, mg/l	35	0.65	4.24	1.83
Total Suspended Solids, mg/l	35	0	26	7
Total Residual Chlorine, mg/l	89	0	.3	.02
Total Chromium, mg/l	35	<0.006	0.0107	0.0067
Total Phosphorus, mg/l	34	0.13	1.09	0.43
Fecal Coliform, #/100 ml	36	<10	30	10
Biochemical Oxygen Demand (BOD_5), mg/l	33	<2.5	11.8	6.4
Discharge 002 (Pond A-3)				
pH, standard units	3	8.2	8.65	N/A
Nitrate as N, mg/l	3	0.66	4.12	2.94
Discharge 003 (Reverse Osmosis Pilot Plant)	During 1991 there were no discharges.			
Discharge 004 (Reverse Osmosis Plant)	During 1991 there were no discharges.			
Discharge 005 (Pond A-4)				
pH, standard units	64	6.3	8.15	N/A
Nitrate as N, mg/l	64	2.28	5.89	4.80
Nonvolatile Suspended Solids, mg/l	64	0	15	2
Discharge 006 (Pond B-5)	During 1991 there were no discharges.			
Discharge 007 (Pond C-2)	There were no discharges January through April 1991.			

a. NPDES permit limitations are presented in Appendix B.
b. C minimum = minimum measured concentration; C maximum = maximum measured concentration; C mean = mean measured concentration.
c. For Fecal Coliform, #/100 ml geometric mean used.
d. Average annual concentration reported for each parameter is an estimate of central tendency (mean value) for all samples collected during the year. This provides an estimate of average effluent water quality for the entire year. The maximum values listed are the highest values observed and represent the worst-case scenario for the entire year. The NPDES permit limits are specified as "Monthly Average" and "Weekly Average" and are measures of central tendency for the shorter time periods as required by the permit. The "Daily Maximum" is the largest value measured during the month. EPA has established limits for these required reporting intervals.
e. Results measured prior to finalization of the FFCA.

Table 3.3-3

Chemical and Biological Constituents in Surface Water Effluents at NPDES Permit Discharge Locations April through December 1991[a, d]

Parameters	Number of Analyses	C minimum[b]	C maximum[b]	C mean[b,c]
Discharge 001 (Pond B-3)				
Nitrate as N, mg/l	88	0.15	13.3	4.48
Total Residual Chlorine, mg/l	244	0	0.41	
Discharge 002 (Pond A-3)				
pH, standard units	39	7.17	8.95	N/A
Nitrate as N, mg/l	39	0.71	3.33	1.62
Discharge 003 (Reverse Osmosis Pilot Plant)		During 1991 there were no discharges.		
Discharge 004 (Reverse Osmosis Plant)		During 1991 there were no discharges.		
Discharge 005 (Pond A-4)				
Total Chromium, µg/l	8	<5	6	6
Discharge 006 (Pond B-5)	During 1991 there were no discharges.			
Discharge 007 (Pond C-2)				
Total Chromium, µg/l	3	<7	<7	<7
Discharge 995 (Sewage Treatment Plant)				
pH, standard units	274	6.2	7.8	N/A
Total Suspended Solids, mg/l	102	0	38	6
Oil and Grease, mg/l	0	0	0	0
Total Phosphorus, mg/l	111	<.1	2.52	0.39
Total Chromium, µg/l	33	<5	8.3	5.9
Fecal Coliform, #/100 ml	116	<1	220	10
Carbonaceous Biochemical Oxygen Demand (BOD_5), mg/l	107	0.1	13.7	3.1

a. NPDES permit limitations are presented in Appendix B.
b. C minimum = minimum measured concentration; C maximum = maximum measured concentration; C mean = mean measured concentration.
c. For Fecal Coliform, #/100 ml geometric mean used.
d. Average annual concentration reported for each parameter is an estimate of central tendency (mean value) for all samples collected during the year. This provides an estimate of average effluent water quality for the entire year. The maximum values listed are the highest values observed and represent the worst-case scenario for the entire year. The NPDES permit limits are specified as "Monthly Average" and "Weekly Average" and are measures of central tendency for the shorter time periods as required by the permit. The "Daily Maximum" is the largest value measured during the month. EPA has established limits for these required reporting intervals.

Table 3.3-4

Plutonium, Uranium, and Americium Concentrations in Surface Water Effluents

Location	Number of Analyses	C minimum[a, b, c]	C maximum[a, b]	C mean[a, c]	Percent of DCG (C mean)
		Plutonium-239, -240 Concentration (x 10^{-9} µCi/ml)[d]			
Pond A-4	55	-0.026 ± 0.016	0.126 ± 0.057	0.002 ± 0.006	0.01
Pond C-1	54	-0.025 ± 0.022	0.230 ± 0.089	0.017 ± 0.010	0.06
Pond C-2	7	-0.007 ± 0.019	0.054 ± 0.037	0.013 ± 0.010	0.04
Walnut Creek at Indiana Street	57	-0.031 ± 0.031	0.045 ± 0.040	0.003 ± 0.003	0.01
		Uranium-233, -234 Concentration (x 10^{-9} µCi/ml)[e]			
Pond A-4	55	0.09 ± 0.09	1.96 ± 0.45	0.74 ± 0.03	0.15
Pond C-1	54	0.00 ± 0.04	4.98 ± 0.87	0.80 ± 0.17	0.16
Pond C-2	7	0.69 ± 0.09	0.95 ± 0.22	0.85 ± 0.09	0.17
Walnut Creek at Indiana Street	56	0.31 ± 0.09	2.45 ± 0.54	0.79 ± 0.04	0.16
		Uranium-238 Concentration (x 10^{-9} µCi/ml)[e]			
Pond A-4	55	0.10 ± 0.08	2.21 ± 0.49	0.74 ± 0.03	0.12
Pond C-1	54	-0.03 ± 0.02	0.92 ± 0.19	0.51 ± 0.05	0.09
Pond C-2	7	0.84 ± 0.20	1.09 ± 0.25	1.00 ± 0.10	0.17
Walnut Creek at Indiana Street	56	0.29 ± 0.11	2.23 ± 0.27	0.78 ± 0.04	0.13
		Americium Concentration (x 10^{-9} µCi/ml)[f]			
Pond A-4	55	-0.038 ± 0.053	0.127 ± 0.056	0.010 ± 0.006	0.03
Pond C-1	52	-0.018 ± 0.019	0.111 ± 0.041	0.008 ± 0.006	0.03
Pond C-2	7	-0.015 ± 0.017	0.066 ± 0.057	0.008 ± 0.012	0.27
Walnut Creek at Indiana Street	55	-0.028 ± 0.018	0.136 ± 0.068	0.010 ± 0.004	0.03

a. C minimum = minimum measured concentration; C maximum = maximum measured concentration. For Pond C-1, C mean refers to calculated mean concentration. Because of intermittent flow meter operations at Pond C-1 during 1991, a volume weighted average was not possible to calculate. For Ponds A-4, C-2, and flow at Walnut Creek at Indiana Street, C mean refers to volume weighted averages.

b. Calculated as 1.96 standard deviations of the individual measurement.

c. Calculated as 1.96 standard deviations of the mean (95% Confidence Interval).

d. Radiochemically determined as plutonium-239 and -240. The DOE Derived Concentration Guide (DCG) for plutonium in water available to members of the public is 30 x 10^{-9} µCi/ml (Appendix B).

e. Radiochemically determined as uranium-233, -234, and -238. The DOE DCG for uranium-233, -234 in water available to members of the public is 500 x 10^{-9} µCi/ml. The DCG for uranium-238 in water is 600 x 10^{-9} µCi/ml (Appendix B).

f. Radiochemically determined as americium-241. The standard calculated DCG for americium in water available to members of the public is 30 x 10^{-9} µCi/ml (Appendix B).

Table 3.3-5
Tritium Concentrations in Surface Water Effluents

Location	Number of Analyses	C minimum[a, c]	C maximum[a, c]	C mean[a, d]	Percent of DCG (C mean)
		Tritium Concentration (x 10^{-9} µCi/ml)[b]			
Pond A-4	206	-251 ± 184	385 ± 224	48 ± 16	0.00
Pond C-1	52	-197 ± 205	234 ± 209	42 ± 47	0.00
Pond C-2	19	-136 ± 177	353 ± 206	81 ± 45	0.00
Walnut Creek at Indiana Street	200	-197 ± 181	332 ± 215	32 ± 17	0.00

a. C minimum = minimum measured concentration; C maximum = maximum measured concentration. For Pond C-1, C mean refers to calculated mean concentration. Due to intermittent flow meter operations at Pond C-1 during 1991, a volume weighted average was not possible to calculate. For Ponds A-4, C-2, and flow at Walnut Creek at Indiana Street, C mean refers to volume weighted averages.

b. The DOE DCG for tritium in water available to the members of the public is 2,000,000 x 10^{-9} µCi/ml (Appendix B).

c. Calculated as 1.96 standard deviations of the individual measurement.

d. Calculated as 1.96 standard deviations of the mean (95% Confidence Interval).

Tritium concentrations in water discharged from these ponds were within range of background concentrations; therefore, cumulative discharge amounts were not calculated. Average annual concentrations of plutonium, uranium, and americium from Ponds A-4 and C-2 for 1987 through 1991 are given in Figures 3.3-2, 3.3-3, and 3.3-4.

During 1991, RFP raw water supply was obtained from Ralston Reservoir and from the South Boulder Diversion Canal. Ralston Reservoir water usually contains more natural uranium radioactivity than the water flowing from the South Boulder Diversion Canal. During the year, uranium, plutonium, americium, and tritium analyses were performed monthly on samples of RFP raw water. Concentrations are presented in Table 3.3-6. These values can be used for comparison with the values measured in the RFP downstream discharge locations (Tables 3.3-4 and 3.3-5).

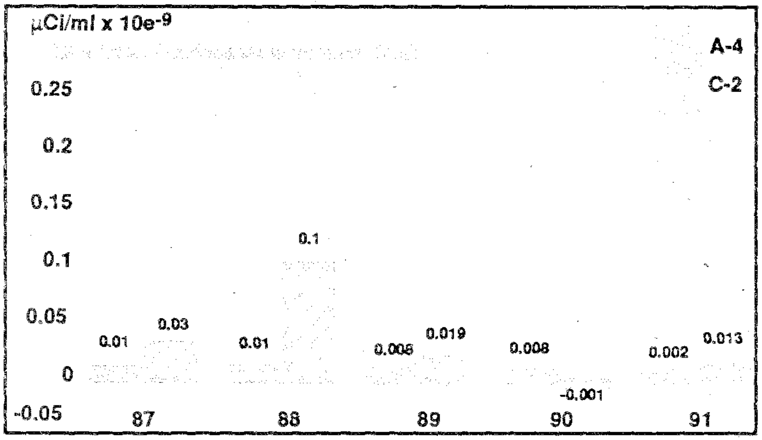


Figure 3.3-2. Plutonium-239, -240

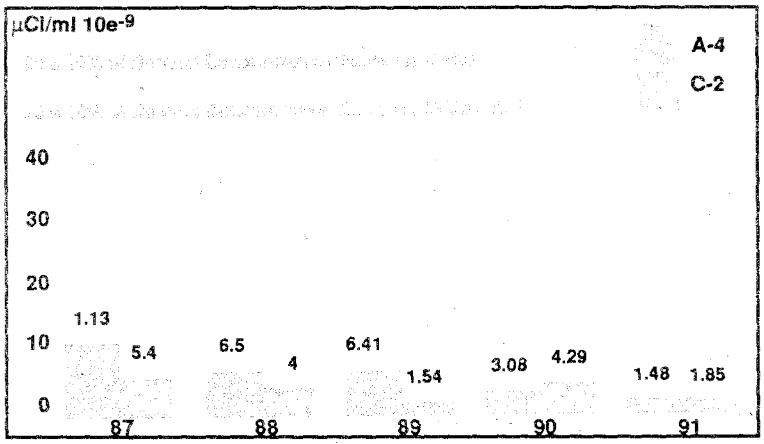


Figure 3.3-3. Uranium-233, -234, -238 Composited

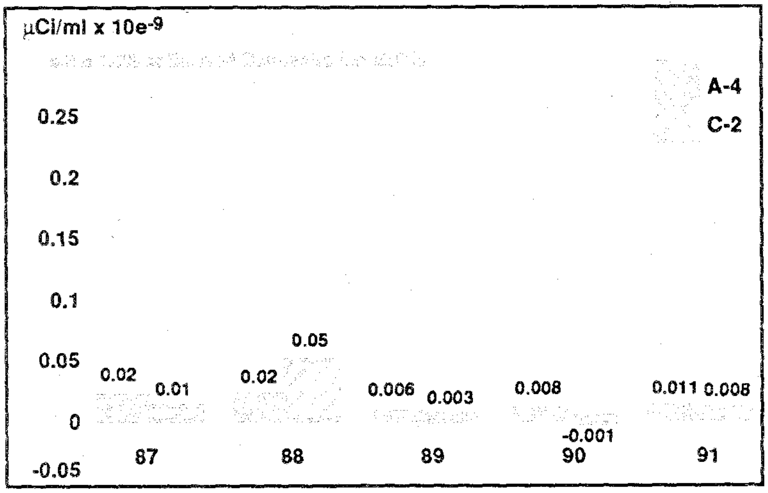


Figure 3.3-4. Americium

Table 3.3-6

Plutonium, Uranium, Americium, and Tritium Concentrations in the Raw Water Supply

Analyte	Number of Analyses	C minimum[a, f]	C maximum[a, f]	C mean[a, g]	Percent of DCG (C mean)
Plutonium Concentration ($\times 10^{-9}$ µCi/ml)[b]	12	-0.021 ± 0.020	0.206 ± 0.082	0.016 ± 0.034	0.05
Uranium-233, -234 Concentration ($\times 10^{-9}$ µCi/ml)[c]	12	0.16 ± 0.07	1.08 ± 0.38	0.44 ± 0.16	0.09
Uranium-238 Concentration ($\times 10^{-9}$ µCi/ml)[c]	12	0.110 ± 0.05	0.870 ± 0.24	0.37 ± 0.13	0.06
Americium Concentration ($\times 10^{-9}$ µCi/ml)[d]	12	-0.025 ± 0.016	0.117 ± 0.074	0.019 ± 0.021	0.06
Tritium Concentration ($\times 10^{-9}$ µCi/ml)[e]	12	-123 ± 169	199 ± 186	-19 ± 53	0.00

a. C minimum = minimum measured concentration; C maximum = maximum measured concentration; C mean = mean calculated concentration.
b. Radiochemically determined as plutonium-239 and -240. The DOE Derived Concentration Guide (DCG) for plutonium in water available to members of the public is 30×10^{-9} µCi/ml (Appendix B).
c. Radiochemically determined as uranium-233, -234 and -238. The DOE DCG for uranium-233, -234 in water available to members of the public is 500×10^{-9} µCi/ml. The DCG for uranium-238 in water is 600×10^{-9} µCi/ml (Appendix B).
d. Radiochemically determined as americium-241. The standard calculated DCG for americium in water available to members of the public is 30×10^{-9} µCi/ml (Appendix B).
e. The DOE DCG for tritium in water available to members of the public is $2{,}000{,}000 \times 10^{-9}$ µCi/ml (Appendix B).
f. Calculated as 1.96 standard deviations of the individual measurement.
g. Calculated as 1.96 standard deviations of the mean (95% Confidence Interval).

COMMUNITY WATER MONITORING

Community water monitoring includes sampling and analysis of public water supplies and tap water from several surrounding communities. Only Great Western Reservoir, one of the water supplies for the city of Broomfield, and Standley Lake Reservoir, a water supply for the cities of Westminster, Thornton, and Northglenn, have the potential to receive runoff from RFP drainage systems. All discharges from RFP detention ponds in 1991 were diverted to the Broomfield Diversion Ditch and did not enter either Great Western Reservoir or Standley Lake Reservoir. The city of Federal Heights purchases a portion of its water supply from the city of Westminster. During 1991, weekly samples were collected and composited into a monthly sample, and analyses were performed for plutonium, uranium, and americium concentrations. Tritium and nitrate (as N) analyses were conducted on weekly grab samples.

Annual background samples were also collected from Ralston, Dillon, and Boulder reservoirs, as well as from South Boulder Diversion Canal at distances ranging from 1 to 60 miles from RFP. Samples were collected to determine background levels for plutonium, uranium, americium, and tritium in water.

Drinking water from Boulder, Broomfield, and Westminster was collected weekly, composited monthly, and analyzed for plutonium, uranium, and americium. Analyses for tritium were performed weekly. Tap water samples were collected quarterly from the communities of Arvada, Denver, Golden, Lafayette, Louisville, and Thornton. These samples were analyzed for plutonium, uranium, americium, and tritium.

Results

Analyses of regional reservoir and drinking water samples are given in Tables 3.3-7 and 3.3-8. Plutonium, uranium, americium, and tritium concentrations for regional reservoirs represented 0.26 percent or less of the DCG. Average plutonium concentration in Great Western Reservoir was 0.001 x 10^{-9} µCi/ml (3.7 x 10^{-5} Bq/l [0.00 percent DCG]), which was within the range of concentrations predicted for Great Western Reservoir in the *Environmental Impact Statement, Rocky Flats Plant Site* (DOE80) based on known low-level plutonium concentrations in reservoir sediments.

Results of plutonium, uranium, americium, and tritium analyses for drinking water in nine communities were 0.17 percent or less of the applicable DCG. Drinking water standards have been adopted by the State of Colorado (CDH77, CDH81) and EPA (EPA76a) for alpha-emitting radionuclides (15 x 10^{-9} µCi/ml [5.55 x 10^{-1} Bq/l]) and for tritium (20,000 x 10^{-9} µCi/ml [7.4 x 10^{2} Bq/l]). These standards exclude uranium and radon. Dunng 1991, the largest mean concentration of plutonium and americium (alpha-emitting radionuclides) for community tap water was 2.87 x 10^{-9}

μCi/ml (1.06×10^{-1} Bq/l). This value was 0.26 percent of the State of Colorado and EPA drinking water standards for alpha activity. Average tritium concentration in Great Western Reservoir, Standley Lake, and in all community tap water samples was 104.0×10^{-9} μCi/ml (3.85 Bq/l) or less. That value is typical of background tritium concentrations in Colorado and is less than 0.01 percent of the State of Colorado and EPA drinking water standards for tritium (CDH81, EPA76a).

Table 3.3-7

Plutonium and Uranium Concentrations in Public Water Supplies

Location	Number of Analyses	C minimum[a, c]	C maximum[a, c]	C mean[a, d]	Percent of DCG (C mean)
Reservoir		**Plutonium-239, -240 Concentration ($\times 10^{-9}$ μCi/ml)[b]**			
Boulder	1	0.004 ± 0.024	0.004 ± 0.024	0.004 ± 0.024	0.01
Dillon	1	0.010 ± 0.029	0.010 ± 0.029	0.010 ± 0.029	0.03
Great Western	12	-0.016 ± 0.020	0.022 ± 0.014	0.001 ± 0.006	0.00
Ralston	1	-0.018 ± 0.015	-0.018 ± 0.015	-0.018 ± 0.015	-0.05
South Boulder Diversion Canal	1[e]				
Standley	12	-0.024 ± 0.013	0.008 ± 0.007	-0.003 ± 0.009	-0.01
Drinking Water					
Arvada	4	-0.022 ± 0.030	0.014 ± 0.029	-0.007 ± 0.016	-0.02
Boulder	12	-0.025 ± 0.012	0.003 ± 0.001	-0.003 ± 0.002	-0.01
Broomfield	12	-0.016 ± 0.010	0.035 ± 0.012	0.004 ± 0.009	0.01
Denver	4	-0.015 ± 0.016	0.014 ± 0.036	-0.002 ± 0.014	-0.01
Golden	4	-0.009 ± 0.020	0.030 ± 0.042	0.011 ± 0.017	0.04
Lafayette	4	-0.023 ± 0.027	0.024 ± 0.032	0.005 ± 0.020	0.02
Louisville	4	-0.030 ± 0.009	0.021 ± 0.051	-0.007 ± 0.021	-0.02
Thornton	4	-0.025 ± 0.018	0.022 ± 0.059	-0.002 ± 0.019	-0.01
Westminster	12	-0.028 ± 0.013	0.045 ± 0.034	0.003 ± 0.013	0.01
Reservoir		**Uranium-233, -234 Concentration ($\times 10^{-9}$ μCi/ml)[f]**			
Boulder	1	0.48 ± 0.15	0.48 ± 0.15	0.48 ± 0.15	0.10
Dillon	1	0.32 ± 0.12	0.32 ± 0.12	0.32 ± 0.12	0.06
Great Western	12	0.36 ± 0.14	0.78 ± 0.17	0.52 ± 0.14	0.10
Ralston	1	1.25 ± 0.17	1.25 ± 0.17	1.25 ± 0.17	0.25
South Boulder Diversion Canal	1[e]				
Standley	12	0.45 ± 0.12	0.91 ± 0.20	0.68 ± 0.135	0.13

Table 3.3-7 (continued)
Plutonium and Uranium Concentrations in Public Water Supplies

Location	Number of Analyses	C minimum[a, c]	C maximum[a, c]	C mean[a, d]	Percent of DCG (C mean)
Drinking Water					
Arvada	4	0.10 ± 0.05	0.51 ± 0.18	0.26 ± 0.18	0.05
Boulder	11	-0.02 ± 0.03	0.40 ± 0.12	0.08 ± 0.08	0.02
Broomfield	12	0.14 ± 0.08	0.58 ± 0.16	0.33 ± 0.15	0.06
Denver	4	0.17 ± 0.07	0.77 ± 0.19	0.46 ± 0.28	0.09
Golden	4	0.25 ± 0.08	0.94 ± 0.25	0.57 ± 0.32	0.11
Lafayette	4	0.03 ± 0.04	0.54 ± 0.19	0.18 ± 0.24	0.04
Louisville	4	-0.03 ± 0.03	0.16 ± 0.07	0.05 ± 0.08	0.01
Thornton	4	0.49 ± 0.13	2.87 ± 0.58	1.31 ± 1.04	0.26
Westminster	12	0.12 ± 0.06	0.47 ± 0.29	0.29 ± 0.07	0.06
Reservoir		Uranium-238 Concentration ($\times 10^{-9}$ µCi/ml)[g]			
Boulder	1	0.28 ± 0.11	0.28 ± 0.11	0.28 ± 0.11	0.06
Dillon	1	0.33 ± 0.10	0.33 ± 0.10	0.33 ± 0.10	0.06
Great Western	11	0.30 ± 0.09	0.73 ± 0.20	0.47 ± 0.07	0.08
Ralston	1	0.87 ± 0.12	0.87 ± 0.12	0.87 ± 0.12	0.17
South Boulder Diversion Canal	1[e]				
Standley	12	0.33 ± 0.12	0.74 ± 0.17	0.57 ± 0.12	0.10
Drinking Water					
Arvada	4	0.07 ± 0.04	0.24 ± 0.07	0.16 ± 0.09	0.03
Boulder	11	-0.02 ± 0.02	0.33 ± 0.10	0.06 ± 0.06	0.01
Broomfield	12	0.07 ± 0.06	0.48 ± 0.10	0.28 ± 0.13	0.06
Denver	4	0.04 ± 0.04	0.37 ± 0.12	0.23 ± 0.14	0.04
Golden	4	0.17 ± 0.07	1.04 ± 0.26	0.55 ± 0.37	0.09
Lafayette	4	0.00 ± 0.02	0.13 ± 0.09	0.06 ± 0.05	0.01
Louisville	4	-0.03 ± 0.02	0.09 ± 0.05	0.02 ± 0.05	0.00
Thornton	4	0.43 ± 0.12	2.16 ± 0.45	1.03 ± 0.76	0.17
Westminster	12	0.13 ± 0.07	0.42 ± 0.13	0.26 ± 0.05	0.04

a. C minimum = minimum measured concentration; C maximum = maximum measured concentration; C mean = mean calculated concentration.

b. Radiochemically determined as plutonium-239 and -240. The DOE DCG for plutonium in water available to members of the public is 30×10^{-9} µCi/ml (Appendix B).

c. Calculated as 1.96 standard deviations of the individual measurements.

d. Calculated as 1.96 standard deviations of the mean (95% Confidence Interval).

e. Location was not flowing at the time annual sampling was scheduled, and location was not revisited. No data to report for 1991.

f. Radiochemically determined as uranium-233, and -234. The DOE DCG for uranium in water available to members of the public is 500×10^{-9} µCi/ml (Appendix B).

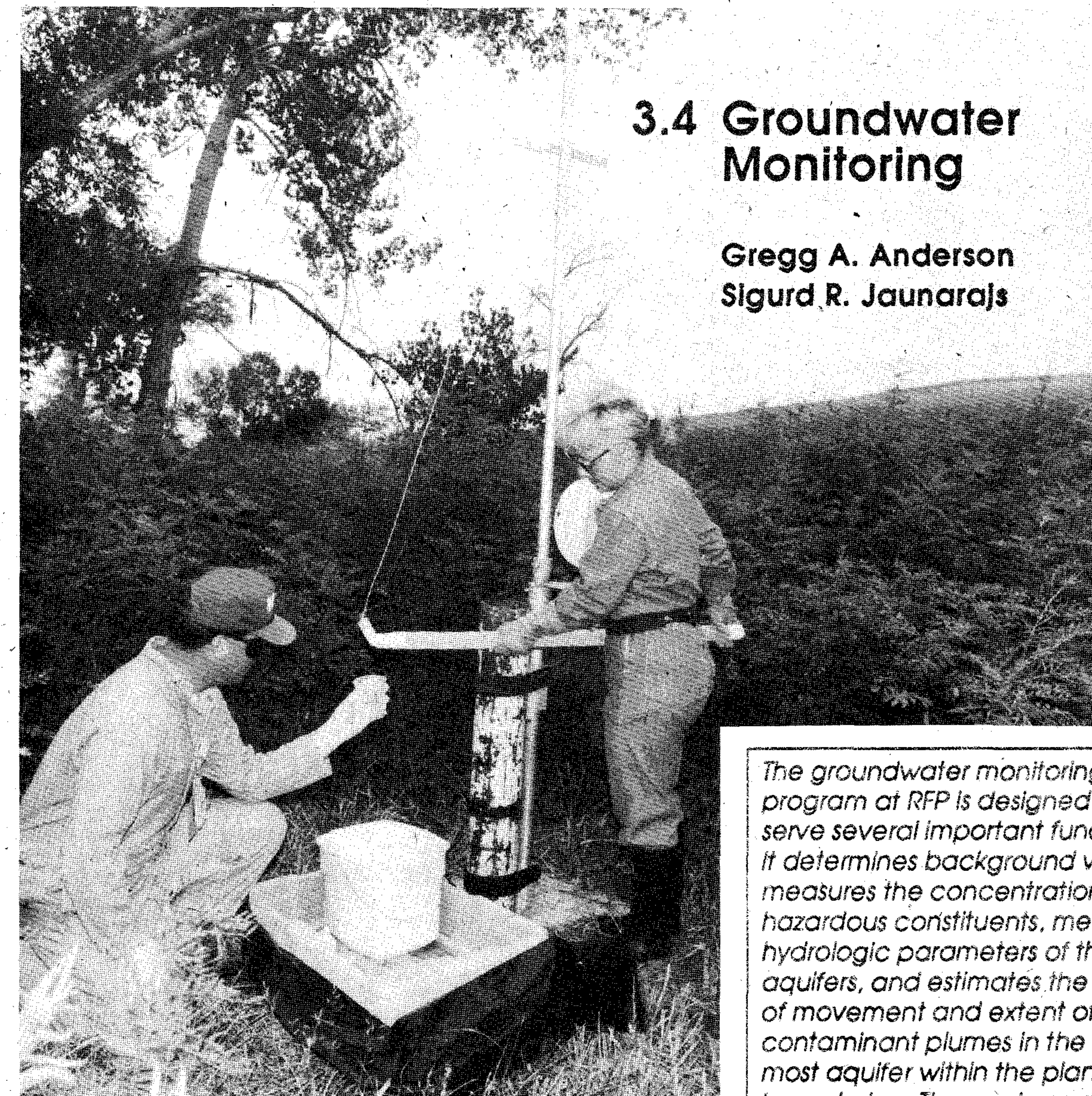
g. Radiochemically determined as uranium-238. The DOE DCG for uranium in water available to members of the public is 600×10^{-9} µCi/ml (Appendix B).

Table 3.3-8
Americium and Tritium Concentrations in Public Water Supplies

Location	Number of Analyses	C minimum[a, c]	C maximum[a, c]	C mean[a,d]	Percent of DCG (C mean)
Reservoir		**Americium Concentration ($x 10^{-9}$ µCi/ml)[b]**			
Boulder	1	-0.013 ± 0.022	-0.013 ± 0.022	-0.013 ± 0.022	-0.04
Dillon	1	0.019 ± 0.032	0.014 ± 0.032	0.019 ± 0.032	0.06
Great Western	12	-0.020 ± 0.006	0.040 ± 0.027	0.005 ± 0.007	0.02
Ralston	1	0.015 ± 0.037	0.015 ± 0.037	0.015 ± 0.037	0.04
South Boulder Diversion Canal	1[e]				
Standley	12	-0.008 ± 0.023	0.015 ± 0.011	-0.001 ± 0.003	0.00
Drinking Water					
Arvada	4	-0.023 ± 0.015	-0.014 ± 0.042	0.018 ± 0.005	0.06
Boulder	12	-0.017 ± 0.021	0.014 ± 0.014	0.001 ± 0.004	0.00
Broomfield	12	-0.007 ± 0.007	0.018 ± 0.016	0.002 ± 0.004	0.01
Denver	4	-0.006 ± 0.025	0.050 ± 0.047	0.028 ± 0.026	0.09
Golden	4	-0.018 ± 0.019	0.005 ± 0.032	-0.003 ± 0.010	-0.01
Lafayette	4	0.001 ± 0.008	0.031 ± 0.049	0.022 ± 0.014	0.07
Louisville	4	-0.022 ± 0.017	-0.001 ± 0.007	-0.011 ± 0.010	-0.04
Thornton	4	-0.017 ± 0.022	0.072 ± 0.076	0.015 ± 0.038	0.05
Westminster	12	-0.007 ± 0.005	0.025 ± 0.018	0.004 ± 0.005	0.01
Reservoir		**Tritium Concentration ($x 10^{-9}$ µCi/ml)[f]**			
Boulder	1	10 ± 189	10 ± 189	10 ± 189	0.00
Dillon	1	147 ± 182	147 ± 182	147 ± 182	0.01
Great Western	53	-174 ± 192	267 ± 192	7 ± 25	0.00
Ralston	1	126 ± 181	126 ± 181	126 ± 181	0.01
South Boulder Diversion Canal	1	-67 ± 181	-67 ± 181	-67 ± 181	0.00
Standley	53	-196 ± 217	394 ± 220	22 ± 27	0.00
Drinking Water					
Arvada	4	-191 ± 201	42 ± 190	-47 ± 98	0.00
Boulder	53	-214 ± 191	200 ± 192	3 ± 26	0.00
Broomfield	53	-194 ± 173	232 ± 216	-17 ± 26	0.00
Denver	4	9 ± 177	184 ± 198	104 ± 86	0.01
Golden	4	-71 ± 206	170 ± 205	34 ± 98	0.00
Lafayette	4	-194 ± 198	85 ± 201	-39 ± 117	0.00
Louisville	4	-146 ± 168	143 ± 203	-5 ± 145	0.00
Thornton	4	57 ± 179	136 ± 194	88 ± 33	0.00
Westminster	53	-202 ± 202	233 ± 199	17 ± 28	0.00

a. C minimum = minimum measured concentration; C maximum = maximum measured concentration; C mean = mean calculated concentration.
b. Radiochemically determined as americium-241. The DOE DCG for americium in water available to members of the public is 30×10^{-9} µCi/ml (Appendix B).
c. Calculated as 1.96 standard deviations of the individual measurements.
d. Calculated as 1.96 standard deviations of the mean (95% Confidence Interval).
e. Location was not flowing at the time annual sampling was scheduled, and location was not revisited. No data to report for 1991.
f. The DOE DCG for tritium in water available to members of the public is $2,000,000 \times 10^{-9}$ µCi/ml (Appendix B).

3. Environmental Monitoring Programs



3.4 Groundwater Monitoring

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Sigurd R. Jaunarajs

The groundwater monitoring program at RFP is designed to serve several important functions. It determines background values, measures the concentration of hazardous constituents, measures hydrologic parameters of the aquifers, and estimates the rate of movement and extent of any contaminant plumes in the uppermost aquifer within the plant boundaries. The analyses derived from the groundwater monitoring program provide the means of evaluating the impacts of plant operations on groundwater and limiting activities that may adversely affect the quality of groundwater in the area.

Geologic Setting

Underlying RFP is a series of stratigraphic units at increasing depths from surface deposits (recent valley fill and loose rock debris) through the Rocky Flats Alluvium, Arapahoe Formation, Laramie Formation, Fox Hills Sandstone to the Pierre Shale (Figure 3.4-1). The Rocky Flats Alluvium, colluvium, and Arapahoe Formation comprise the uppermost hydrologic unit where potential groundwater contamination might occur at RFP. A description of the geology of RFP is given in the *Geologic Characterization of the Rocky Flats Plant* (EG911).

The Rocky Flats Alluvium is composed of cobbles, coarse gravel, sand, and gravely clay, varying in thickness across RFP from 103 feet on the west side, to less than 10 feet in the central area, and 45 feet on the east side. The Arapahoe Formation is approximately 120 feet thick in the central portion of RFP. It consists mainly of fluvial claystone overbank deposits and lesser amounts of sandstone channel deposits. The sandstones range from very fine grained to conglomerate.

Hydrogeology

The Rocky Flats Alluvium and the weathered subcropping Arapahoe Sandstones are in hydraulic connection and together represent the "uppermost aquifer," which is an unconfined flow system (Figure 3.4-1).

Figure 3.4-1. Generalized Cross Section of the Stratigraphy Underlying the RFP

The bedrock sandstones of the Arapahoe Formation are isolated within intervals of claystone. Groundwater contained in those bedrock sandstones is confined and represents a lower flow system. Table 3.4-1 gives the relative hydraulic conductivities associated with the lithologic units present at RFP.

In the spring and early summer, the Rocky Flats Alluvium and Arapahoe Formation, located in the central and eastern portion of RFP, are recharged by precipitation and groundwater lateral flow. In the late summer and early fall these formations are recharged mostly by groundwater lateral flow. In the stream drainages, groundwater discharges at seeps that are common at the base of the Rocky Flats Alluvium and where individual sandstones become exposed to the surface.

Table 3.4-1

Hydraulic Conductivities of Lithologic Units

Lithologic Unit	Hydraulic Conductivity
Rocky Flats Alluvium	1 x 10^{-5} cm/sec (10.4 ft/yr)
Subcropping Arapahoe sandstones	1 x 10^{-5} cm/sec (10.4 ft/yr)
Unweathered sandstones	1 x 10^{-6} cm/sec (1.04 ft/yr)
Weathered and unweathered claystone	1 x 10^{-7} to 10^{-8} cm/sec, (0.104 to 0.0104 ft/yr)

The present understanding of the hydrogeologic relationships indicates that there are no known bedrock pathways through which groundwater contamination may directly leave RFP and migrate into a confined aquifer system offsite (EG91I).

Monitoring Procedures

Monitoring wells and piezometers in place at RFP by the end of 1991 are shown in Figure 3.4-2. Table 3.4-2 shows groundwater wells installed by area at RFP.

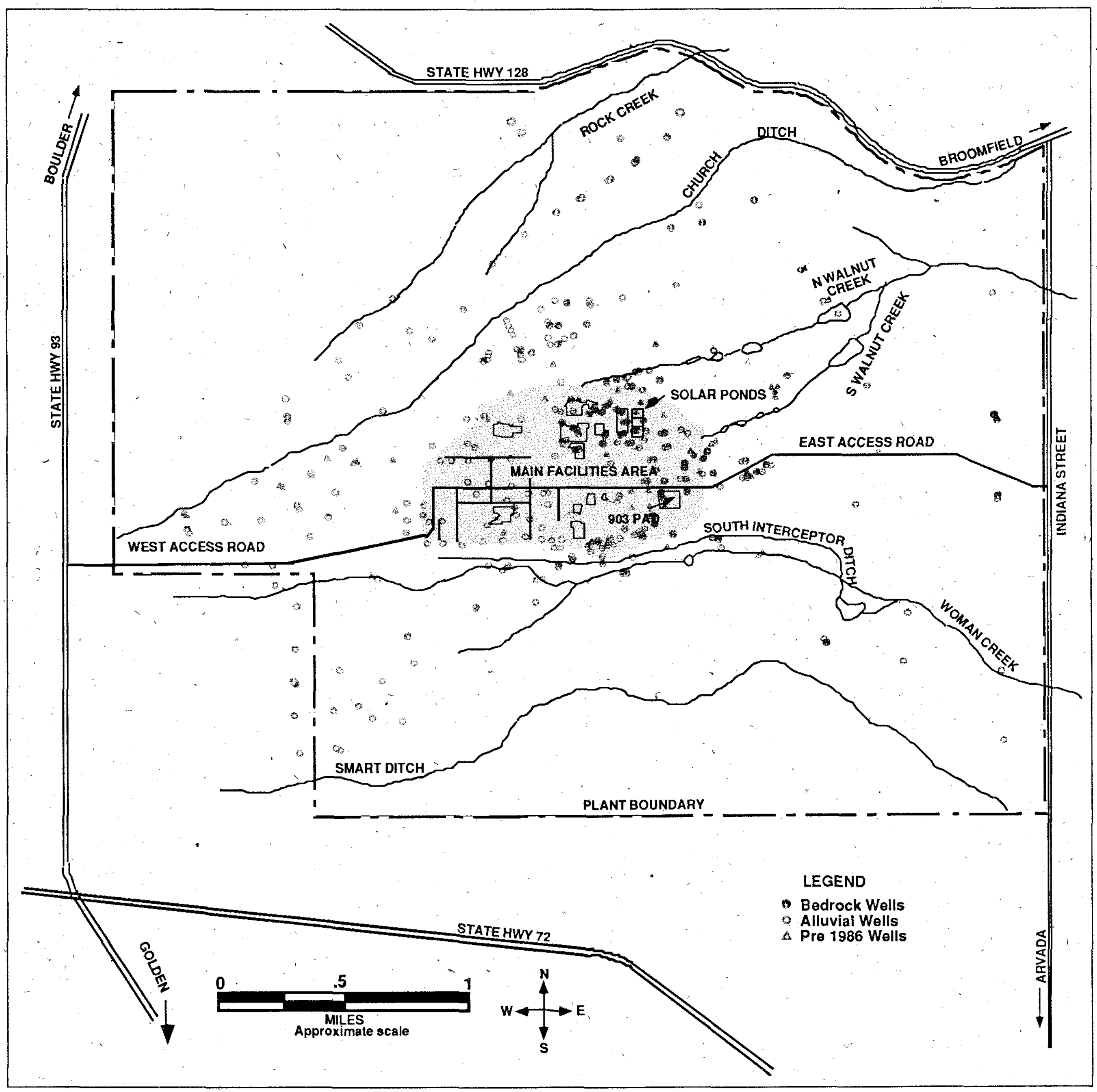


Figure 3.4-2. Location of Monitoring Wells

Table 3.4-2
Groundwater Monitoring Wells

Location	Wells Installed in 1991	Wells Installed in 1990	Wells Installed in 1989	Wells Installed before 1989	Total Number of Well Installations
Solar Ponds	-	-	32	33	65
Present Landfill	-	-	13	25	38
West Spray Field	-	-	8	18	26
Process Waste Lines	-	-	3	9	12
903 Pad	-	-	-	15	15
Mound	22	-	-	14	36
East Trenches	25	-	8	27	60
881 Hillside	30	-	3	37	70
Piezometers	-	4	39	-	43
Background	3	-	50	1	54
East Buffer	7	-	4	14	25
Landfill Siting	-	14	-	-	14
Totals	87	18	160	193	458

Groundwater samples are collected quarterly from alluvial and bedrock wells and analyzed for parameters shown in Table 3.4-3. These wells are spatially distributed throughout RFP to provide the necessary coverage to satisfy RCRA/CERCLA and CDH guidelines for monitoring groundwater at hazardous waste sites. Some wells are used to help characterize hydrogeologic conditions at RFP. Others are used to monitor background groundwater quality. Samples are not collected from the remaining wells at RFP either because they contain no water or because construction details of the well are unknown or of questionable quality.

Quarterly water-level measurements are taken to adequately assess groundwater flow directions. These data are used to evaluate trends in groundwater quality and contaminant migration in the uppermost, unconfined aquifer.

Table 3.4-3
Site Chemical Constituents Monitored in Groundwater

Metals

Cesium (Cs)
Lithium (Li)[b]
Molybdenum (Mo)
Strontium (Sr)
Tin (Sn)[a]

Target Analyte List:
Aluminum (Al)
Antimony (Sb)
Arsenic (As)
Barium (Ba)
Beryllium (Be)
Cadmium (Cd)
Calcium (Ca)
Chromium (Cr)
Cobalt (Co)
Copper (Cu)
Iron (Fe)
Lead (Pb)
Magnesium (Mg)
Manganese (Mn)
Mercury (Hg)
Nickel (Ni)
Potassium (K)
Selenium (Se)
Silver (Ag)
Sodium (Na)
Thallium (Tl)
Vanadium (V)
Zinc (Zn)

Organics [d]

Target Compound List - Volatiles:
Chloromethane (CH_3CL)
Bromomethane (CH_3Br)
Vinyl Chloride (C_2H_3CL)
Chloroethane (C_2H_5CL)
Methylene Chloride (CH_2CL_2)
Acetone
Carbon Disulfide
1,1-Dichloroethane (1,1-DCA)
1,1,-Dichloroethene (1,1-DCE)
trans-1,2-Dichloroethene
1,2-Dichloroethene (total) (total 1,2-DCE)
Chloroform ($CHCl_3$)
1,2-Dichloroethane (1,2-DCA)
2-Butanone (MEK)
1,1,1-Trichloroethane (1,1,1-TCA)
Carbon Tetrachloride (CCl_4)
Vinyl Acetate
Bromodichloromethane
1,1,2,2-Tetrachloroethane
1,2-Dichloropropane (1,2-DCP)
trans-1,3-Dichloropropene
Trichloroethene (TCE)
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
cis-1,3-Dichloropropene
Bromoform (CBr_4)
2-Hexanone
4-Methyl-2-pentanone
Tetrachloroethene (PCE)
Toluene (C_7H_8)
Chlorobenzene (C_6H_5CL)
Ethyl Benzene
Styrene
Total Xylenes

Radionuclides [e]

Gross Alpha
Gross Beta
Uranium-233, -234, -235, and -238
(U-233, -234, -235; and -238)
Americium-241 (Am-241)
Plutonium-239, -240 (Pu-239, -240)
Strontium-89, -90 (Sr-89, -90)[f]
Cesium-137 (Cs-137)
Tritium (H-3)
Radium-226, -228 (Ra-226, -228)[g]

Indicators

Total Dissolved Solids (TDS)
pH[a]

Field Parameters

pH
Specific Conductance
Temperature
Dissolved Oxygen
Alkalinity

Anions

Carbonate (CO_3)
Bicarbonate (HCO_3)
Chloride (Cl)
Sulfate (SO_4)
Nitrate/Nitrite (NO_2/NO_3 as N)
Cyanide (CN)[c]
Fluoride (F)
Orthophosphates (PO_4)

a. Not analyzed before 1989.
b. Before 1989, lithium was only analyzed during fourth quarter 1987 and first quarter 1988.
c. Cyanide was not analyzed during fourth quarter 1987.
d. Not analyzed in background samples in 1989.
e. Dissolved radionuclides replaces total radionuclides (except tritium) beginning with the third quarter 1987; however, total Pu and Am were collected starting in third quarter 1990.
f. Strontium-89, -90 was not analyzed during first quarter 1988.
g. Not analyzed before1989, and only analyzed if gross alpha exceeds 5 pCi/l.

NOTES:
* Total suspended solids and phosphate were analyzed in 1986 only; orthophosphates were analyzed in 1990 and 1991.
* Chromium (VI) was analyzed during fourth quarter 1987 only.

RESULTS

The final IAG (Section 2, "Compliance Summary") divides RFP into 16 operable units for study and restoration. Individual maps of all 16 OUs are located at the end of Section 4 "Remediation." The following section discusses results of groundwater investigations on OUs 1, 2, 4, 7, and 11. OUs 4, 7, and 11 were identified collectively as OU 3 under the former draft IAG. Results of samples taken from background wells used to characterize the spatial and temporal variability of naturally occurring constituents are given in the document titled *Background Geochemical Characterization Report for 1989* (EG90d).

Groundwater investigations and restoration activities at RFP follow a five-phase plan to identify contamination, design and implement treatment procedures, and monitor adequacy of restoration actions. This process includes establishment of groundwater quality standards that are specific to each OU and reflect state and federal requirements. No specific standards have been established for OUs at RFP, although possible limits have been identified pursuant to the CERCLA requirements that remedial actions comply with ARAR federal laws or more stringent, promulgated state laws. Site-specific groundwater standards and classifications were established by the CWQCC in early 1991 and became effective April 30, 1991. The standards apply to all unconfined groundwater in the alluvial materials, the Arapahoe aquifer, and the Laramie-Fox Hills aquifer.

The alluvial aquifers are classified Domestic and Agricultural Use - Quality and Surface Water Protection. The Arapahoe and Laramie-Fox Hills aquifers are classified Domestic and Agricultural Use - Quality.

Operable Unit 1

881 Hillside. The report titled *Phase III RFI/RI Work Plan, Rocky Flats Plant, 881 Hillside Area (Operable Unit No. 1)* (EG91g) contains information on groundwater quality at OU 1. The Phase III RFI/RI field work was completed in 1991. Boreholes and 30 additional monitoring wells were installed in 1991 to characterize the upper hydrostratigraphic unit.

Shallow groundwater under the 881 Hillside is contaminated with VOCs, inorganics (including some metals), and elevated levels of uranium. The contaminants of most concern are VOCs in the unconfined groundwater system within the boundaries of Individual Hazardous Substance Sites (IHSSs) 119.1 and 119.2 (Figure 4-1, page 156) in the eastern portion of this OU. These areas were used for barrel waste storage from 1967 to 1972. Figure 3.4-3 shows approximate outlines of the groundwater contaminant plumes on the plantsite and depicts the extent of contaminant movement under the 881 Hillside. Organic contaminants detected in the highest concentrations in 1991 were 1,1,1-trichloroethane, 1,1-dichloroethene, and trichloroethene.

Concentrations of VOCs diminish downgradient of IHSSs 119.1 and 119.2, becoming equal to or below detection limits (5 μg/l) within 200 ft of the original storage areas.

Elevated concentrations of inorganic constituents also were found in the eastern portion of OU 1, where analytes detected above background levels included total dissolved solids (TDS), metals (nickel, strontium, selenium, zinc, and copper), and uranium.

Operable Unit 2

903 Pad, Mound, and East Trenches Areas. The report titled *Phase II RFI/RI Work Plan, Rocky Flats Plant, 903 Pad, Mound, and East Trenches Areas, Operable Unit No. 2* (EG91h) contains information on groundwater quality at OU 2. Phase II RFI/RI work was initiated in 1991. Groundwater in the upper hydrostratigraphic unit, which is composed of alluvial materials and shallow subcropping sandstones, is contaminated with VOCs, inorganics, dissolved metals, and some radionuclides.

Inorganics and dissolved metals commonly occurring above background levels include TDS, strontium, barium, copper, and nickel, and to a lesser extent, chromium, manganese, selenium, lead, zinc, and molybdenum. The majority of the radionuclide contamination is uranium-238. Americium and plutonium are also present in some groundwater samples.

Contaminants of most concern are VOCs; those detected in 1991 include tetrachloroethene and trichloroethene. Figure 3.4-3 depicts groundwater contaminant plumes on the plantsite and indicates the approximate extent of contamination at OU 2. Certain inorganic parameters and radionuclides were elevated above background levels in OU 2, but they did not appear to exist as a well-defined plume of contamination. Investigations are underway to further characterize these plumes and the magnitude and extent of contamination.

Operable Units 4, 7, and 11

Solar Ponds, Present Landfill, West Spray Field. OUs 4, 7, and 11 are RCRA-regulated units. The purpose of groundwater monitoring in these units is to assess impacts of waste management activities on groundwater quality in the uppermost aquifer beneath these units. The report titled *1991 Annual RCRA Groundwater Monitoring Report for Regulated Units at Rocky Flats Plant* (EG92b) presents results of 1991 interim-status quarterly groundwater monitoring. Data are presented for groundwater elevations, flow rates, and quality analyses. A comparison is made between analyte concentrations upgradient of the unit and those downgradient of the unit to evaluate the impact of waste management activities on groundwater quality. The following sections highlight results of groundwater monitoring in OUs 4, 7, and 11 in 1991.

Solar Ponds (OU 4). Groundwater assessment monitoring continues to be performed at the Solar Evaporation Ponds area to further assess the levels, extent, and migration characteristics of contamination in the uppermost aquifer beneath this unit. A total of 62 monitoring wells presently exists in the Solar Evaporation Ponds area (29 of these monitoring wells are alluvial [shallow] wells and 33 are bedrock [deep] wells). Water elevation data collected throughout 1991 reveals that groundwater flow across the Solar Evaporation Ponds area is generally in an easterly direction; however, it diverges along two major subsurface flowpaths. One flowpath is northeasterly toward North Walnut Creek and the other is southeasterly toward South Walnut Creek. Groundwater flow velocities calculated for surficial materials are 1.2 feet per year for the

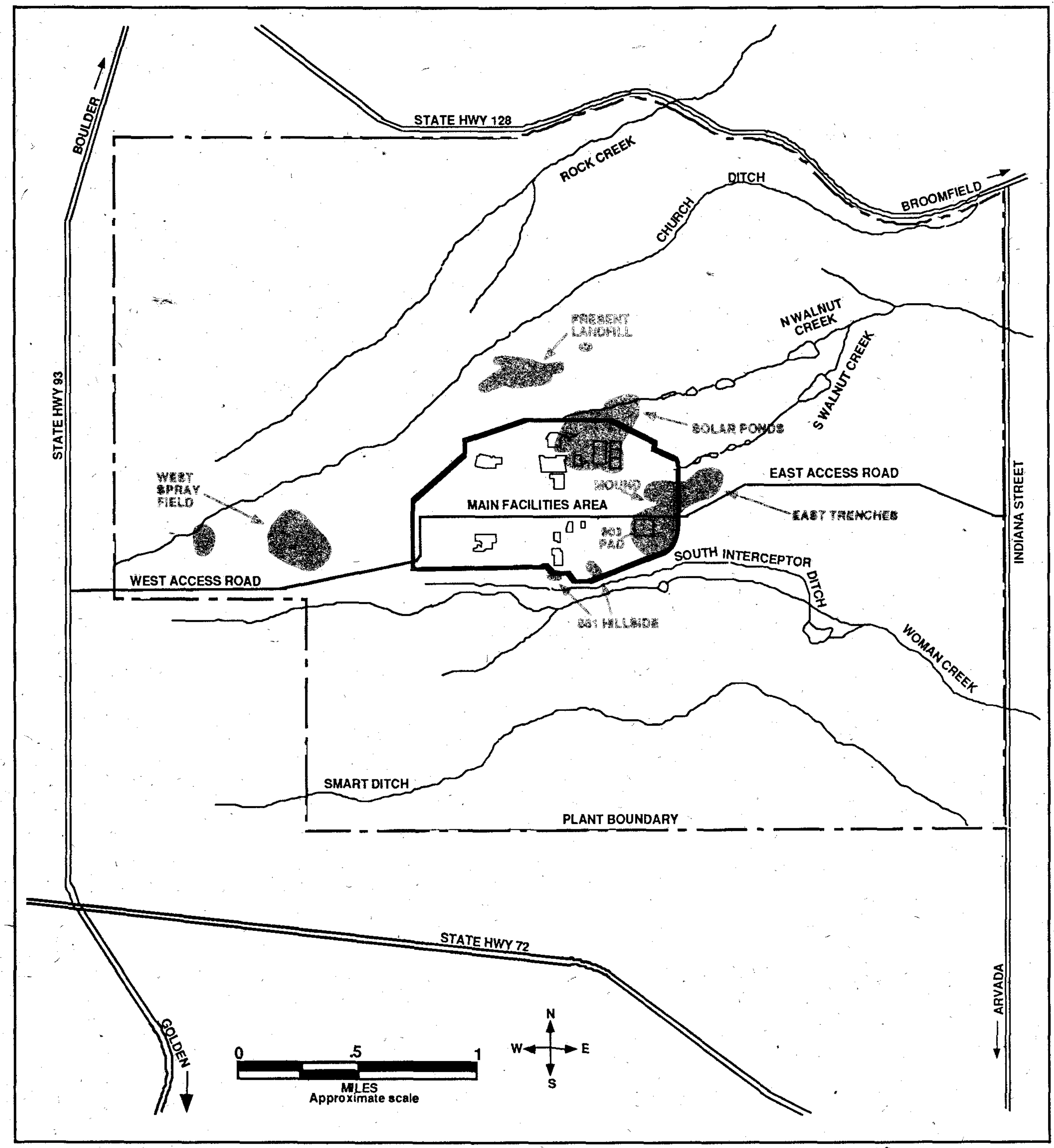


Figure 3.4-3. Location of Known Groundwater Contamination Plumes

northeasterly flowpath and 0.72 feet per year for the southeasterly flowpath. Groundwater elevations are presented in Figure 3.4-4 for surficial materials during the first quarter of 1991.

A statistical comparison of downgradient water quality compared with upgradient groundwater quality indicates that groundwater in downgradient wells screened in the uppermost aquifer north, east, and southwest of the ponds is impacted with nitrate/nitrite, total dissolved solids, total suspended solids, sulfate, dissolved radionuclides, and several dissolved metals. Dissolved radionuclides detected in surficial wells downgradient and in the immediate vicinity of the Solar Ponds during 1991 included uranium-233, -234 (as high as 1.052 x 10^{-7} µCi/ml), uranium-235, uranium-238 (7.470 x 10^{-8} µCi/ml), and tritium. Total radionuclides detected in the uppermost aquifer include americium-241 (1.360 x 10^{-10} µCi/ml) and in one well, plutonium-239, -240 (3.790 x 10^{-10} µCi/ml). Concentrations and distribution of uranium-233, -234 (reported in pCi/l) in the Solar Evaporation Ponds area are presented in Figure 3.4-5. VOCs detected in surficial wells in the vicinity of the Solar Ponds are shown in Figure 3.4-6 and include trichloroethene, tetrachloroethene, carbon tetrachloride, chloroform, and several others.

The Present Landfill (OU 7). The Present Landfill is undergoing groundwater monitoring to assess the level, extent, and migration characteristics of contamination in the uppermost aquifer beneath the unit. Groundwater elevation data collected in 1991 indicates that groundwater beneath the landfill tends to flow easterly through surficial geologic materials toward the landfill pond as shown for first quarter 1991 in Figure 3.4-7. Close to the pond, groundwater flows southeasterly and northeasterly toward the pond. Flow velocities have been calculated at 128 feet per year for groundwater in surficial materials. Groundwater flow characteristics in the weathered bedrock are similar to those observed in the overlying surficial materials. Influencing the natural flow of groundwater and surface water in the area are several engineering control systems installed to intentionally redirect flow around

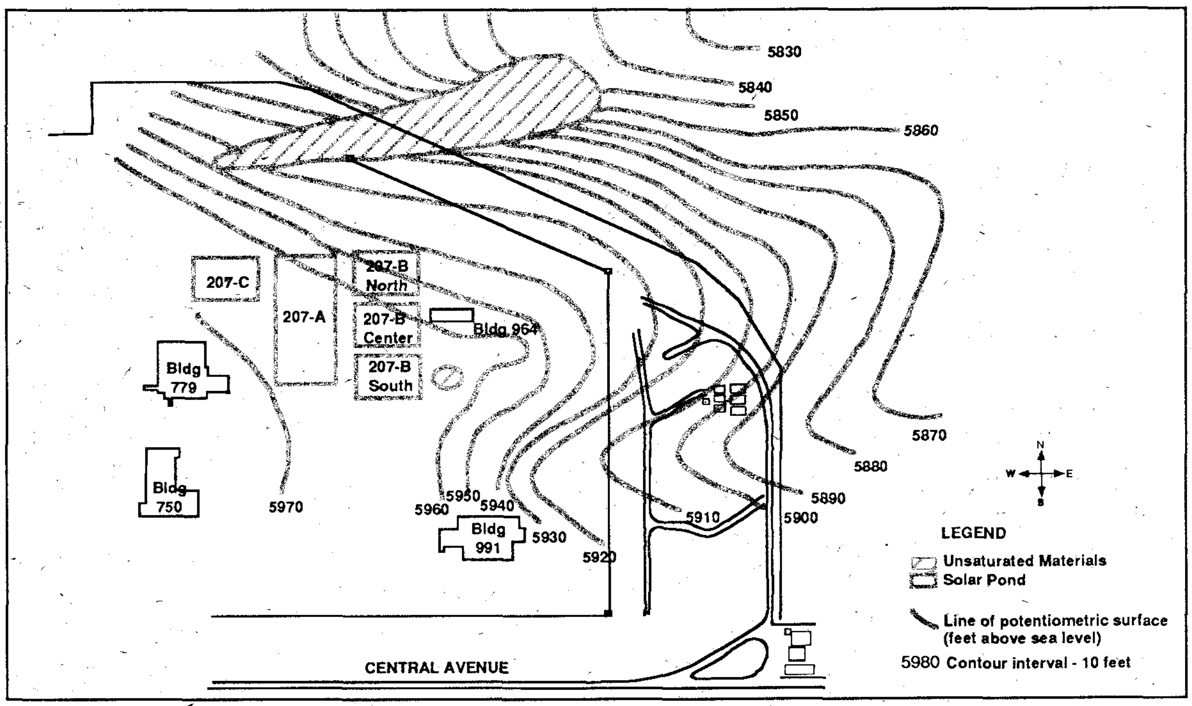


Figure 3.4-4. Solar Evaporation Ponds Potentiometric Surface in Surficial Materials

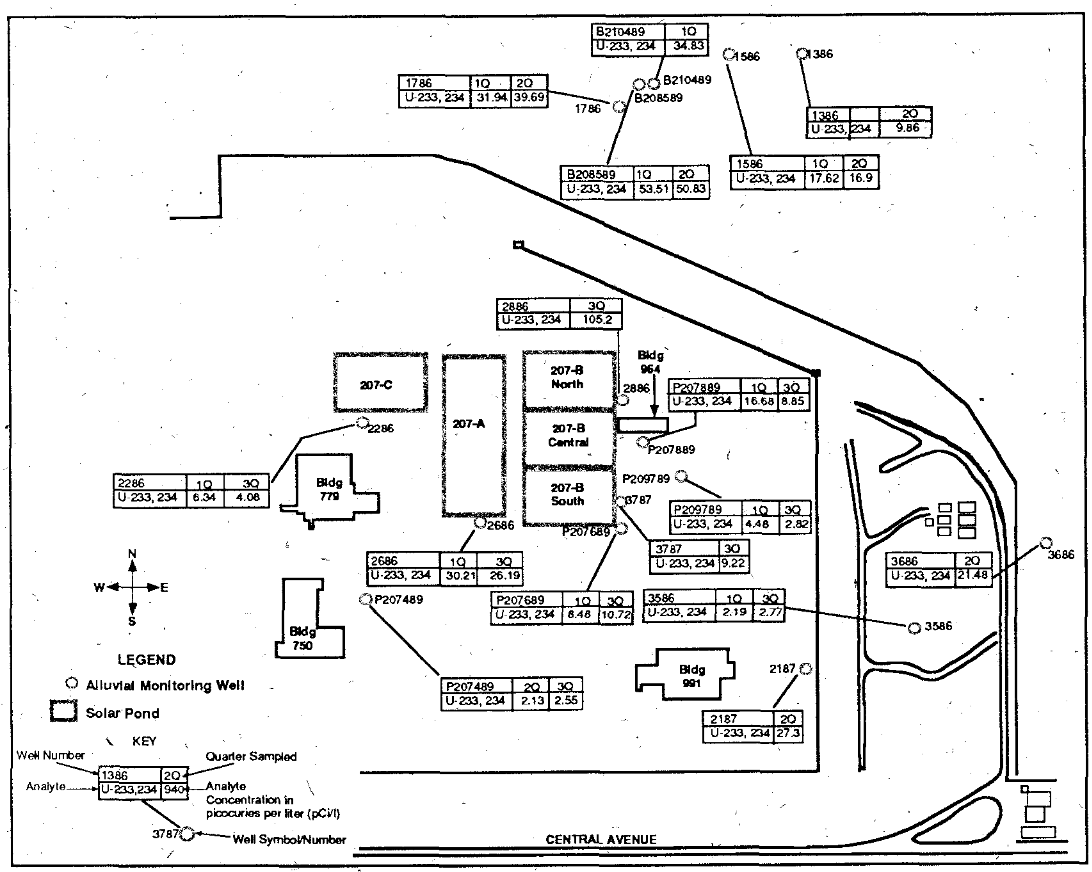


Figure 3.4-5. Solar Evaporation Ponds Dissolved Uranium-233, -234 Detected in the Uppermost Aquifer

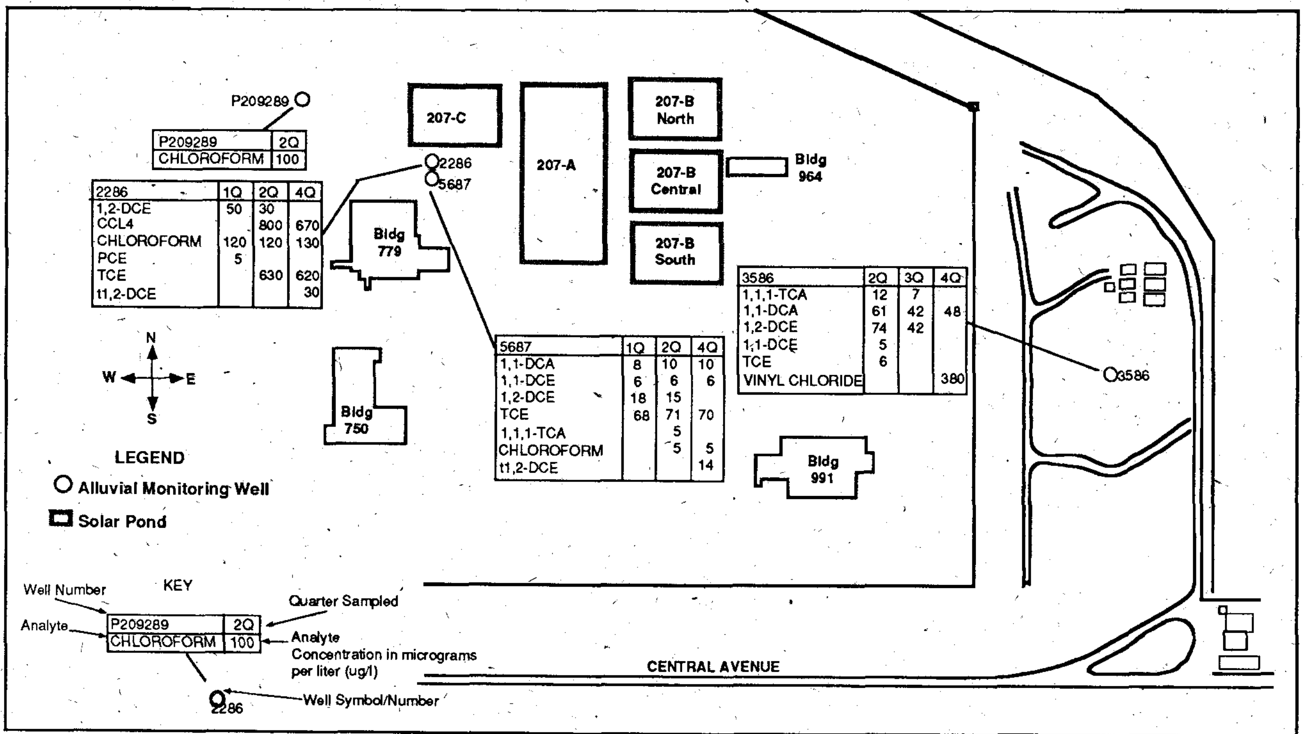


Figure 3.4-6. Solar Evaporation Ponds Volatile Organic Compounds Detected in the Uppermost Aquifer

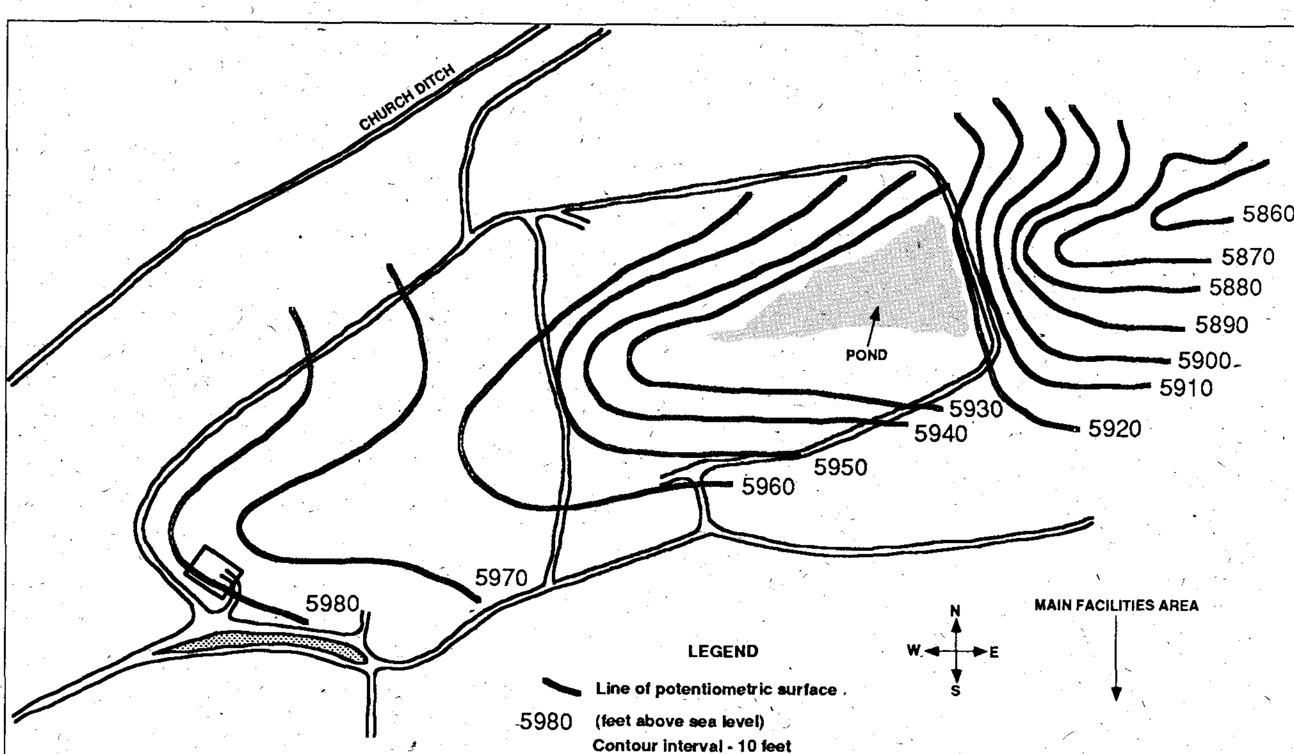


Figure 3.4-7. Present Landfill Potentiometric Surface in Surficial Materials

the landfill. Engineering control systems include pond embankments, a leachate/groundwater intercept system, a surface water interceptor ditch, and a buried slurry wall. Assessment of the 1991 data suggests that groundwater outside of the landfill is diverted around the landfill wastes and is discharged into the landfill pond. Landfill contaminants migrate with the groundwater flow through the leachate collection system toward the landfill pond. Water is retained within the pond, where it either evaporates directly or is evaporated via spray irrigation onto the hillsides adjacent to the pond. The effectiveness of the leachate/groundwater intercept system is still being evaluated. Data from 1991 suggest, however, that the groundwater intercept system may not be diverting all groundwater away from the north and south sides of the landfill, and the leachate collection system may function intermittently on the north side of the landfill.

Thirty-one shallow and four deep groundwater wells are monitored quarterly at the Present Landfill. Groundwater quality data in downgradient wells statistically compared with those upgradient of the landfill in 1991 show that the landfill contributes several dissolved metals, dissolved radionuclides, and several inorganic analytes to the uppermost aquifer downgradient of the landfill. Specifically, the landfill is observed to impact groundwater quality through increased concentrations of bicarbonate, calcium, chloride, fluoride, magnesium, sodium, and total dissolved solids. Additionally, the landfill appears to contribute dissolved metals, primarily antimony, chromium, lithium, potassium, and strontium. Gross alpha and gross beta activities were also statistically higher in downgradient wells than in upgradient wells. No VOCs were detected in the uppermost aquifer downgradient of the landfill in 1991.

Within the confines of the Present Landfill, the nature of groundwater contamination is characterized by detections of VOCs, radionuclides, and concentrations of metals and inorganic analytes higher than in upgradient wells. Dissolved radionuclides detected in 1991 in and adjacent to the landfill include tritium (up to

1.834 x 10^{-6} µCi/ml), strontium-89, -90 (1.117 x 10^{-8} µCi/ml), uranium-233, -234 (up to 3.22 x 10^{-8} µCi/ml), uranium-235 (up to 8.0 x 10^{-10} µCi/ml), uranium-238 (up to 2.05 x 10^{-8} µCi/ml), and radium-226 (up to 7.7 x 10^{-10} µCi/ml). Total radionuclides detected include americium-241 (up to 8.0 x 10^{-11} µCi/ml), cesium-137 (1.06 x 10^{-9} µCi/ml), and plutonium-239, -240 (up to 1.8 x 10^{-10} µCi/ml). Radionuclides were detected in wide area across the landfill site. Figure 3.4-8 shows the distribution and concentration of radionuclides at the landfill with concentrations given in pCi/l. Detections of VOCs in 1991 occurred primarily in wells in the southern portion of the landfill. A number of different compounds were detected including carbon tetrachloride, trichloroethene, and tetrachloroethene. The distribution and concentrations (reported in mg/l) of detected VOCs are presented in Figure 3.4-9.

West Spray Field (OU 11)

Groundwater monitoring at the West Spray Field is being conducted to provide data for assessment of the level, extent, and migration characteristics of contamination in the uppermost aquifer beneath this unit. Groundwater flow in the uppermost aquifer is relatively uniform and occurs in an east-northeasterly direction. Groundwater flow rates were calculated at 28 feet per year in 1991. Fourteen alluvial wells and three bedrock wells are routinely sampled at the West Spray Field. A potentiometric surface map showing groundwater elevations in the uppermost aquifer is presented for first quarter 1991 in Figure 3.4-10.

Groundwater quality in the uppermost aquifer in downgradient wells was statistically compared with that in upgradient wells. This comparison revealed that concentrations of several analytes were higher in downgradient wells than in wells upgradient of the West Spray Field. Those analytes included iron, manganese, zinc, Isobutylmethyl Ketone (MIBK), carbon disulfide, trichloroethene (TCE), magnesium, and strontium. Carbon disulfide is produced by the decomposition of organic matter in an anaerobic environment; its presence in the West Spray Field does not represent contamination from waste management activities.

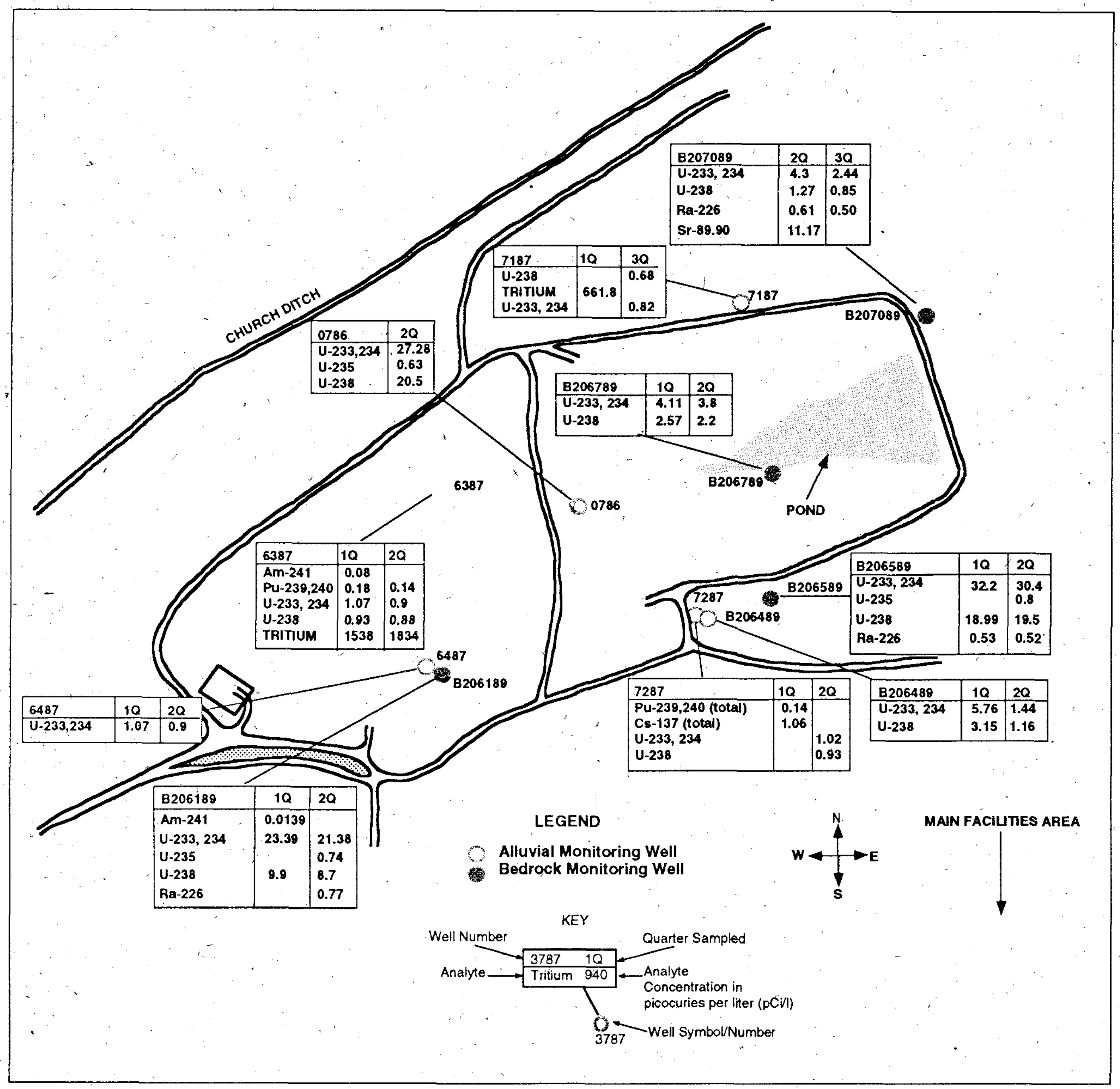


Figure 3.4-8. Present Landfill Radionuclides in the Uppermost Aquifer

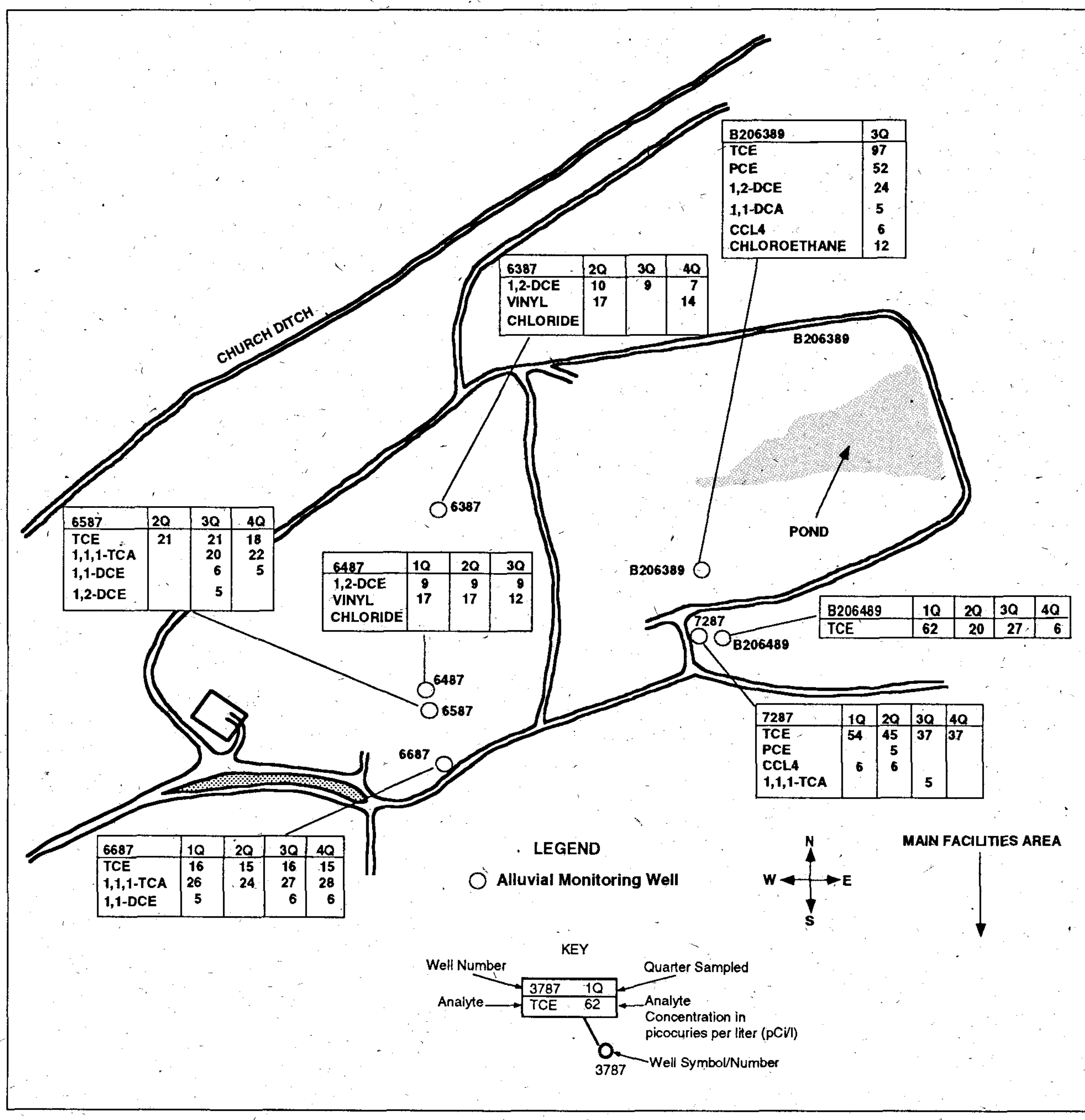


Figure 3.4-9. Present Landfill Volatile Organic Compounds Detected in the Uppermost Aquifer

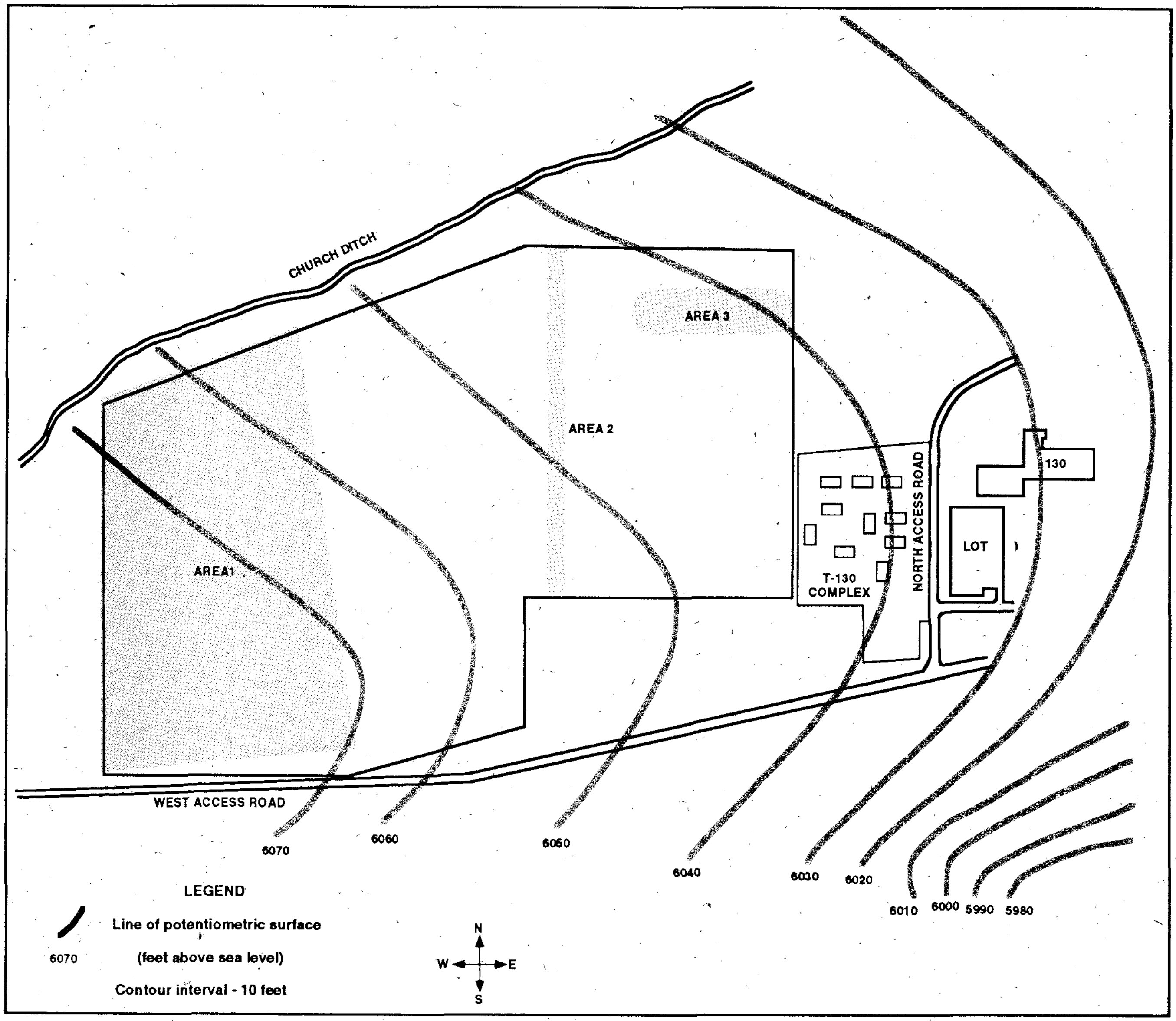


Figure 3.4-10. West Spray Field Potentiometric Surface in Surficial Materials

Within and adjacent to the West Spray Field, groundwater quality has been impacted by VOCs, dissolved radionuclides, a few dissolved metals, and inorganic analytes. VOCs detected include TCE, MIBK, and toluene at levels just above the detection limit. Dissolved radionuclides detected include uranium-233, -234 (up to 1.62×10^{-9} µCi/ml), and uranium-238 (up to 1.15×10^{-9} µCi/ml). Total radionuclides in the uppermost aquifer within the West Spray Field included americium-241 (up to 9.6×10^{-11} µCi/ml), and plutonium-239 (3.47×10^{-10} µCi/ml). Distribution and concentrations of VOCs and radionuclides (reported in pCi/l) detected in 1991 in the uppermost aquifer are shown in Figures 3.4-11. and 3.4-12, respectively. Inorganic analytes detected at elevated levels within the West Spray Field include fluoride, chloride, bicarbonate, sodium, sulfate, nitrate/nitrite, orthophosphate, and total suspended solids. Assessments made in 1991 conclude that waste management activities did contribute to the presence of these inorganic compounds at the West Spray Field.

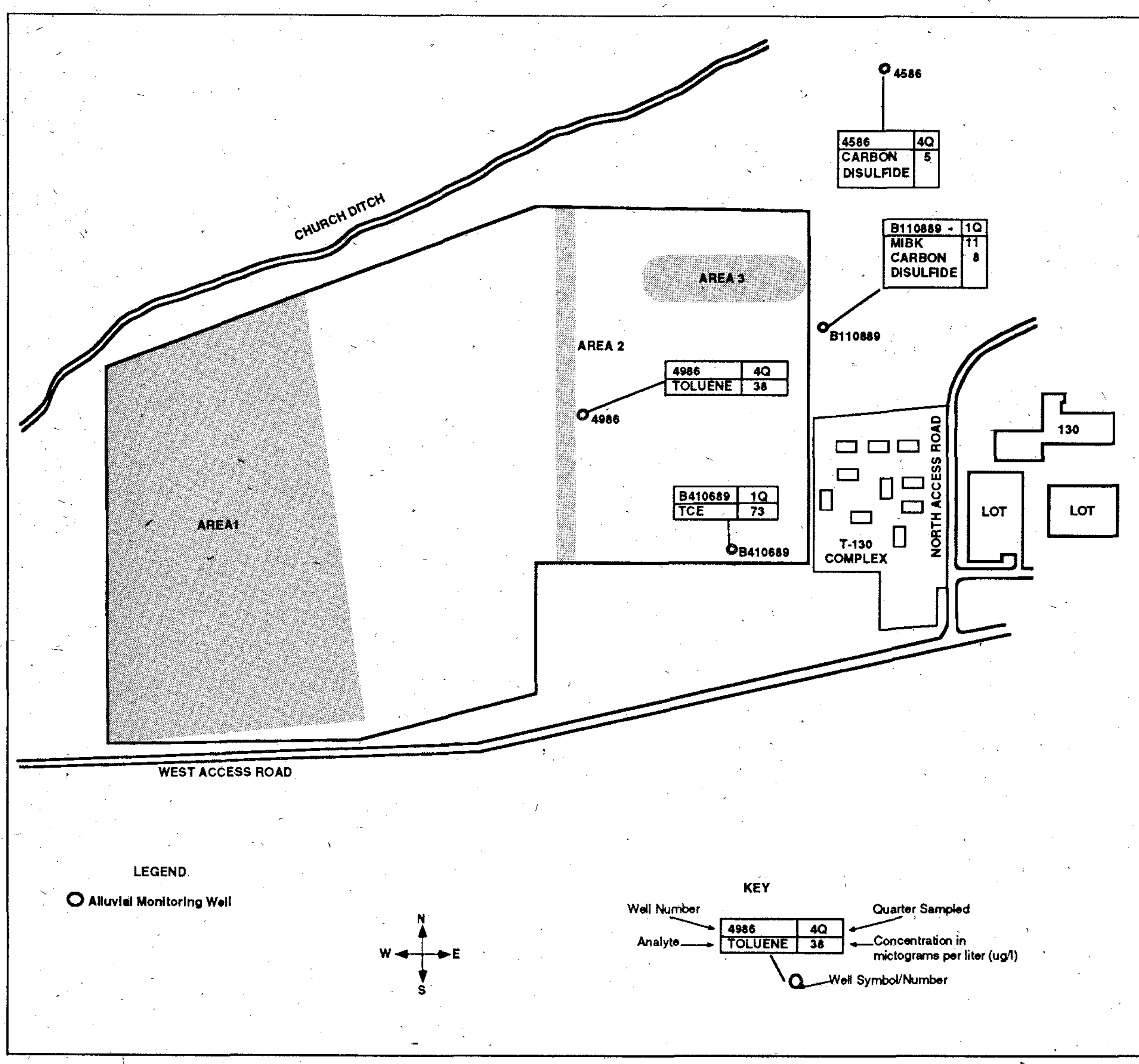


Figure 3.4-11. West Spray Field Volatile Organic Compounds Detected in the Uppermost Aquifer

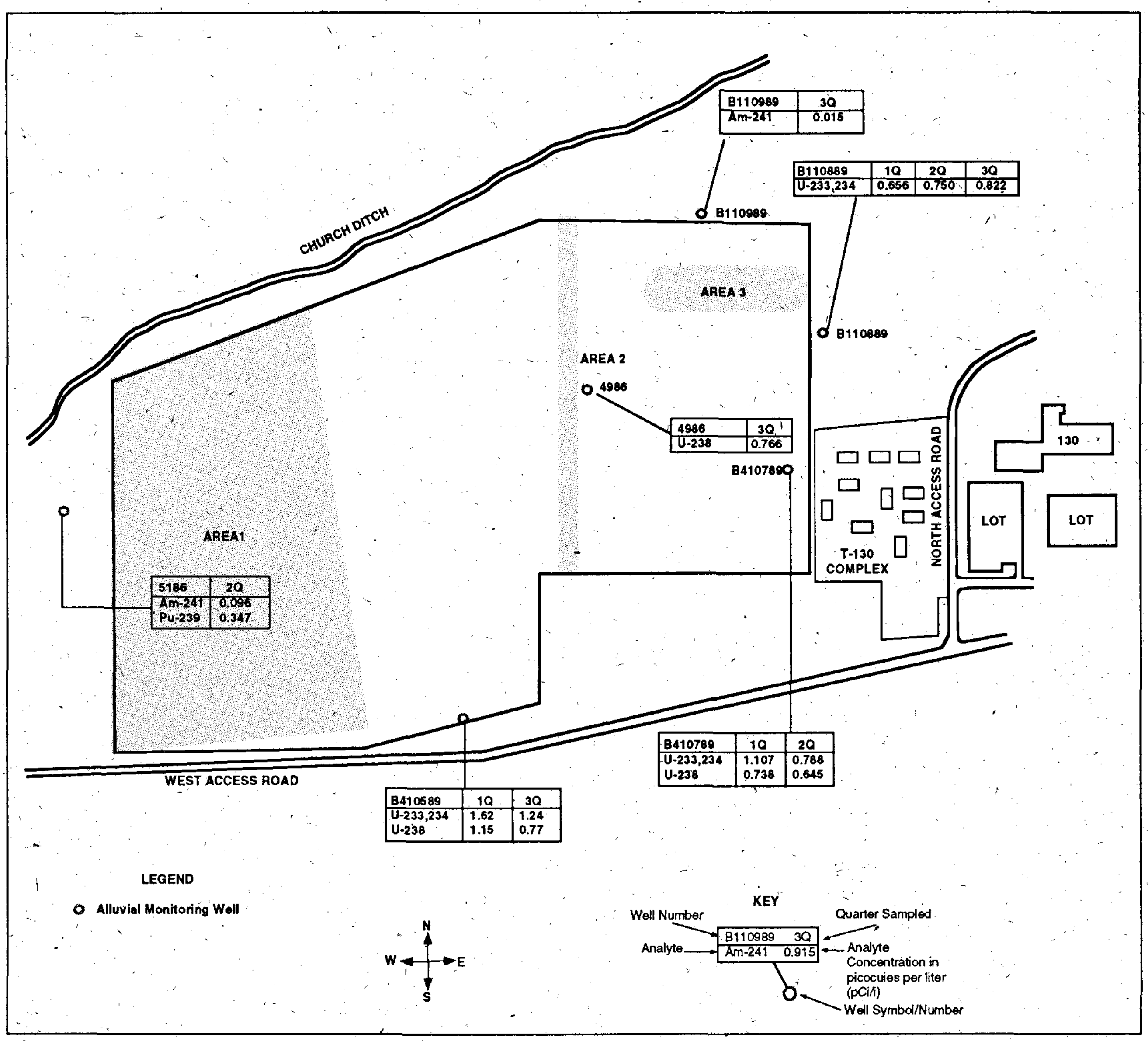
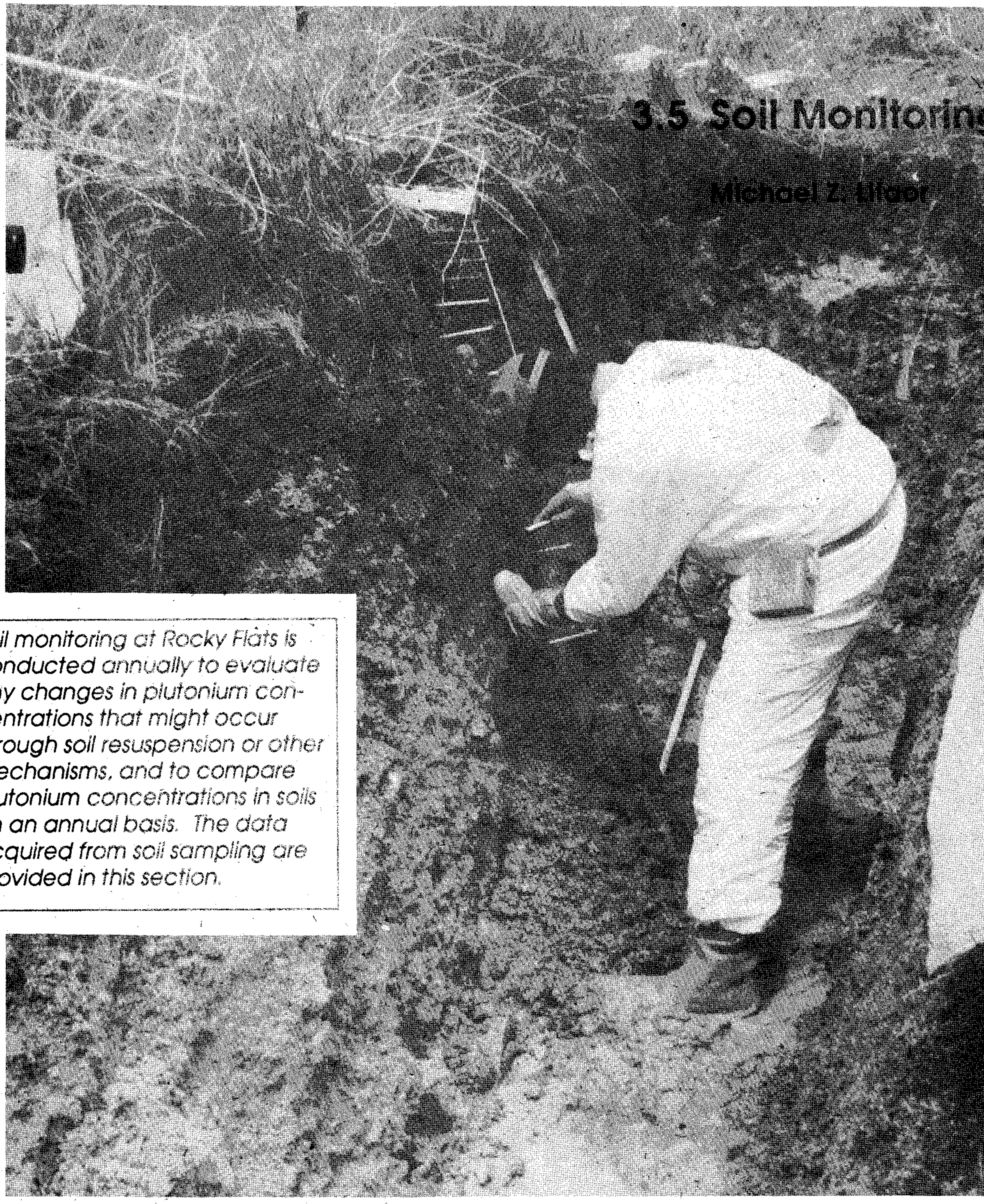


Figure 3.4-12. West Spray Field Radionuclides Detected in the Uppermost Aquifer

3.5 Soil Monitoring

Michael Z. Litaor



Soil monitoring at Rocky Flats is conducted annually to evaluate any changes in plutonium concentrations that might occur through soil resuspension or other mechanisms, and to compare plutonium concentrations in soils on an annual basis. The data acquired from soil sampling are provided in this section.

OVERVIEW

The Soil Monitoring Program has been conducted since 1972, excepting the period between 1978 and 1983. Soils were sampled at RFP in September 1991 at 40 sites located within concentric circles, approximately 1.6- and 3.2-kilometer (1- and 2-mile) radii from the center of RFP (Figure 3.5-1). Along each circle, sampling locations were spaced at 18° increments and designated accordingly (e.g., location 1-018 refers to the inner circle [#1] at 18° northeast). The soil samples were collected by driving a 10- by 10-centimeter (4- by 4-inch) cutting tool 5 centimeters (2 inches) deep into undisturbed soil. The soil sample within the tool cavity was collected and placed into a new 1-gallon stainless steel can. Ten subsamples were collected from the corners and the center of two 1-meter squares, which were spaced 1 meter apart. Each set of 10 subsamples was composited (5,000 cubic centimeters [cm^3]) for soil radionuclides analysis. Laboratory analysis was performed to determine plutonium concentration, expressed as pCi/g.

RESULTS

Soil plutonium concentrations for 1984 through 1991 are presented in Table 3.5-1. Figure 3.5-1 depicts the location of the soil sample sites, as well as the mean and standard deviation of soil plutonium concentrations from 1984 through 1991. Samples taken in 1991 from the inner concentric circle ranged from 0.04 pCi/g to 9.76 pCi/g. In previous years the highest soil plutonium concentration was found at sites 1-090 and 1-108 (Figure 3.5-2). Since the 1990 soil sampling, sample location 1-090 was relocated approximately 200 meters to the north of its original location. The older site is located in an area currently under intensive study as part of the IAG.

Samples from the outer concentric circle ranged from 0.01 pCi/g to 3.61 pCi/g. The highest plutonium concentrations were found in soil samples from the eastern portion of the buffer zone (Figures 3.5-1 and 3.5-2). These sample locations are east and southeast of the major source of plutonium contamination in the soil

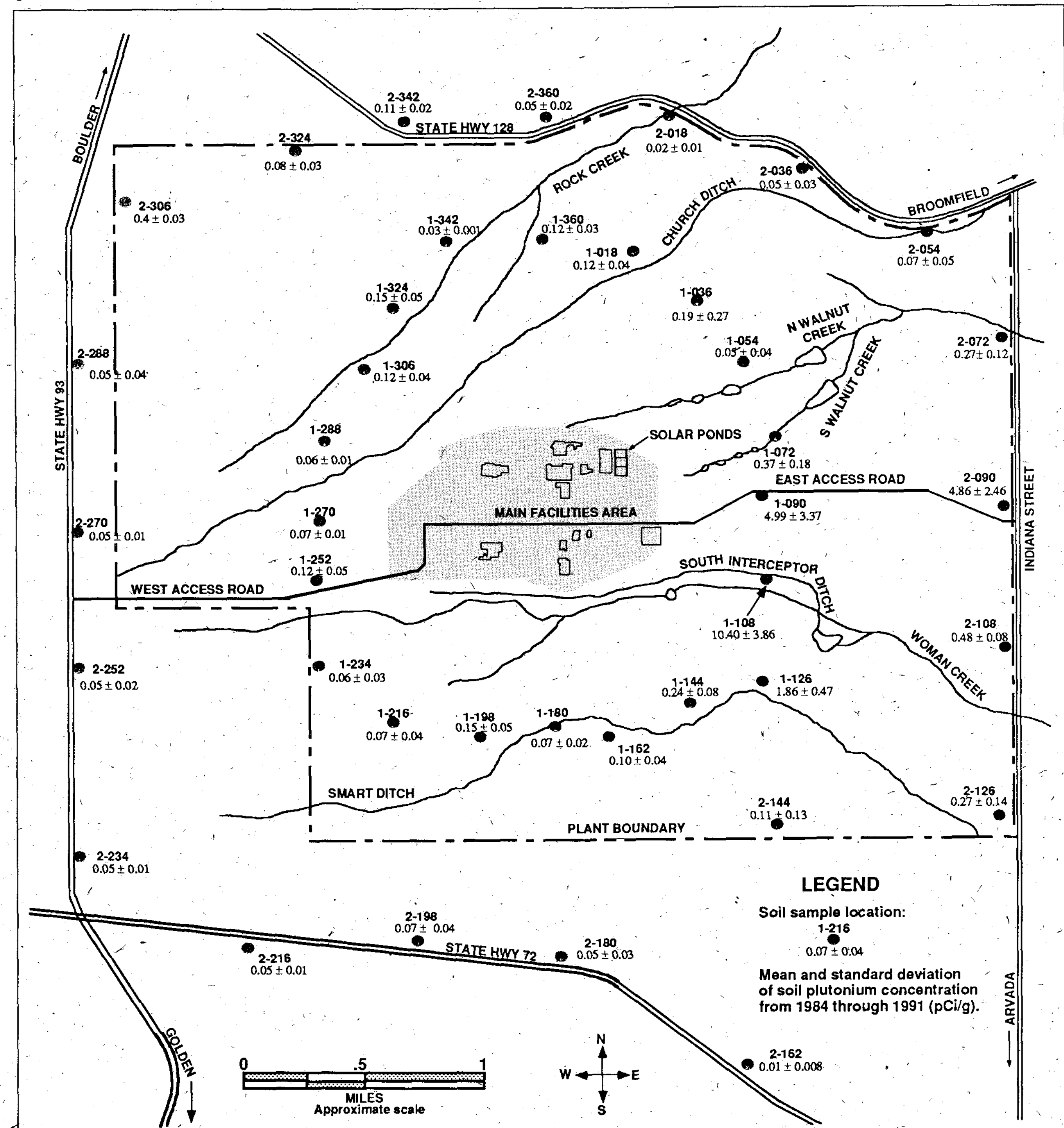


Figure 3.5-1. Soil Sampling Locations

environment at RFP. Plutonium contamination probably originated from an area known as the 903 Pad, where steel drums were used to store plutonium-contaminated industrial oils from 1958 to 1968. Leakage from these drums contaminated surface soils and plants. Plutonium particles entrapped in the fine fraction of top soil horizons were subsequently airlifted by winds and deposited on soils in an east and southeast-trending plume (KR70). Table 3.5-1 indicates that data from previous years have consistently shown elevated plutonium concentrations in soils from these sites.

The plutonium concentration in soils east and southeast of the 903 Pad varied somewhat between years (Table 3.5-1). Each monitoring site was adequately sized (30 by 30 meters) to allow yearly selection of nonoverlapping sample areas. Since the sampling location varied among years, small microtopographical variation was introduced, which affected wind deposition and resuspension rates of plutonium. In addition, natural variability in erosional and faunal activities, as well as sampling and analytical error, contribute to the

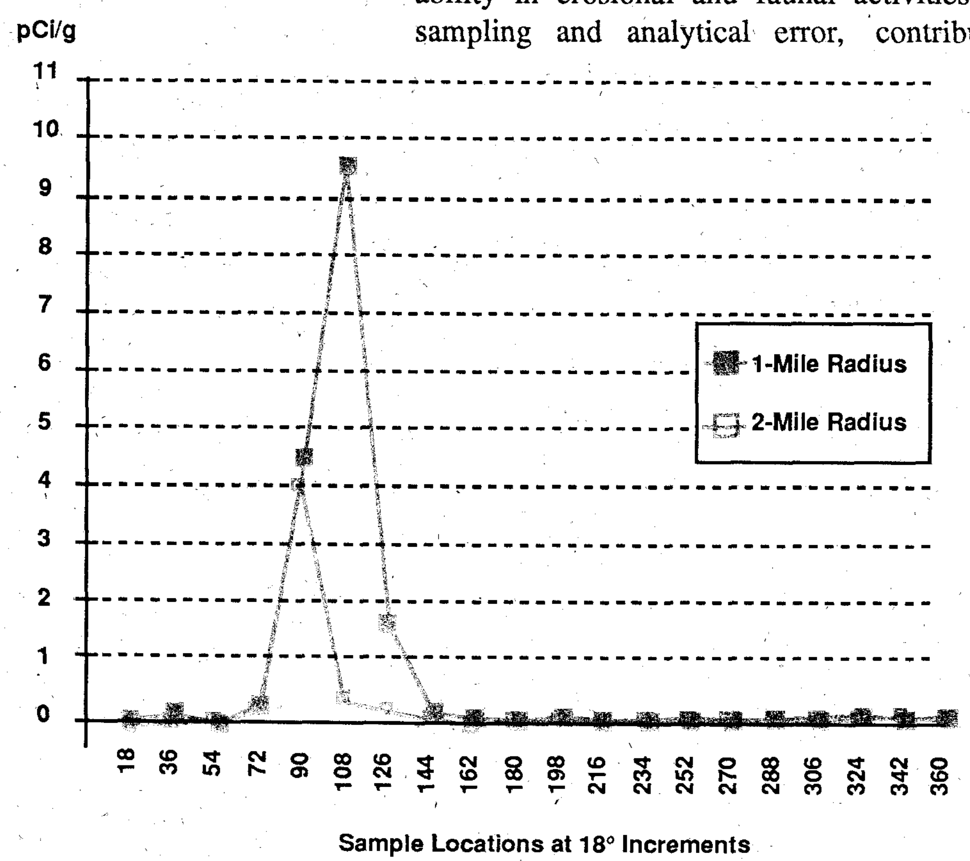


Figure 3.5-2. Mean Plutonium Concentration in Soils at 1- and 2-Mile Radii from the RFP, 1984 - 1991

Table 3.5-1

Plutonium Concentration in Soil Samples at 1 and 2 Miles from the Plant Center

Inner Circle:

Location	1984 Pu pCi/g[a,b,c,d]			1985 Pu pCi/g[a,b,c,d]			1986 Pu pCi/g[a,b,c,d]			1987 Pu pCi/g[a,b,c,d]		
1-018	0.08	±	0.02	0.15	±	0.02d	0.15	±	0.02	0.18	±	0.02
1-036	0.03	±	0.01	0.08	±	0.01	0.10	±	0.02	0.06	±	0.01
1-054	0.00	±	0.01	0.02	±	0.01	0.04	±	0.01	0.04	±	0.01
1-072	0.6	±	0.05	0.32	±	0.03	0.63	±	0.06	0.51	±	0.05
1-090	7.7	±	0.5	1.00	±	0.09	7.40	±	0.62	7.05	±	0.77
1-108	15.0	±	0.9	13.0	±	1.30	15.0	±	1.40	2.37	±	0.21
1-126	2.1	±	0.1	1.90	±	0.17	1.90	±	0.18	2.75	±	0.28
1-144	0.29	±	0.03	0.32	±	0.03	0.27	±	0.02	0.36	±	0.04
1-162	0.14	±	0.02	0.10	±	0.01	0.08	±	0.01	0.17	±	0.02
1-180	0.09	±	0.02	0.06	±	0.01	0.06	±	0.01	0.10	±	0.01
1-198	0.22	±	0.03	0.16	±	0.02	0.16	±	0.02	0.21	±	0.02
1-216	0.05	±	0.02	0.05	±	0.01	0.10	±	0.01	0.16	±	0.02
1-234	0.13	±	0.02	0.05	±	0.01	0.04	±	0.01	0.05	±	0.01
1-252	0.17	±	0.02	0.14	±	0.02	0.11	±	0.01	0.21	±	0.03
1-270	0.06	±	0.02	0.07	±	0.01	0.08	±	0.01	0.09	±	0.01
1-288	0.04	±	0.01	0.05	±	0.01	0.05	±	0.01	0.06	±	0.01
1-306	0.14	±	0.02	0.09	±	0.01	0.17	±	0.02	0.21	±	0.03
1-324	0.13	±	0.02	0.15	±	0.02	0.21	±	0.02	0.24	±	0.03
1-342	0.04	±	0.01	0.02	±	0.01	0.03	±	0.01	0.03	±	0.01
1-360	0.10	±	0.02	0.11	±	0.01	0.19	±	0.02	0.16	±	0.02

Outer Circle:

Location	1984 Pu pCi/g[a,b,c,d]			1985 Pu pCi/g[a,b,c,d]			1986 Pu pCi/g[a,b,c,d]			1987 Pu pCi/g[a,b,c,d]		
2-018	0.00	±	0.01	0.04	±	0.01	0.03	±	0.01	0.04	±	0.01
2-036	0.02	±	0.01	0.02	±	0.01	0.07	±	0.01	0.10	±	0.01
2-154	0.03	±	0.01	0.03	±	0.01	0.05	±	0.01	0.10	±	0.01
2-072	0.4	±	0.04	0.33	±	0.03	0.23	±	0.02	0.36	±	0.04
2-090	10.0	±	0.6	2.50	±	0.25	5.30	±	0.48	4.48	±	0.52
2-108	0.46	±	0.04	0.41	±	0.04	0.46	±	0.04	0.57	±	0.06
2-126	0.14	±	0.02	0.42	±	0.04	0.44	±	0.05	0.40	±	0.04
2-144	0.02	±	0.01	0.04	±	0.01	0.04	±	0.01	0.08	±	0.01
2-162	0.00	±	0.01	0.01	±	0.00	0.02	±	0.01	0.03	±	0.01
2-180	0.02	±	0.01	0.11	±	0.01	0.04	±	0.01	0.03	±	0.01
2-198	0.05	±	0.02	0.02	±	0.01	0.08	±	0.01	0.14	±	0.02
2-216	0.04	±	0.01	0.04	±	0.01	0.06	±	0.01	0.07	±	0.01
2-234	0.04	±	0.01	0.05	±	0.01	0.05	±	0.01	0.07	±	0.01
2-252	0.09	±	0.01	0.04	±	0.01	0.07	±	0.01	0.06	±	0.01
2-270	0.04	±	0.01	0.04	±	0.01	0.06	±	0.01	0.08	±	0.01
2-288	0.01	±	0.01	0.04	±	0.01	0.05	±	0.01	0.13	±	0.02
2-306	0.00	±	0.01	0.06	±	0.01	0.02	±	0.01	0.08	±	0.01
2-324	0.08	±	0.02	0.04	±	0.01	0.09	±	0.01	0.08	±	0.01
2-342	0.13	±	0.02	0.13	±	0.01	0.12	±	0.01	0.14	±	0.02
2-360	0.02	±	0.01	0.09	±	0.01	0.05	±	0.01	0.08	±	0.01

a. Not blank corrected.
b. Samples to a depth of 5 cm.
c. Concentrations are for the fraction of soil measuring less than 2 mm diameter.
d. Error term represents two standard deviations.

Table 3.5-1 (Continued)

Plutonium Concentration in Soil Samples at 1 and 2 Miles from the Plant Center

Inner Circle:

Location	1988 Pu pCi/g[a,b,c,d]			1989 Pu pCi/g[a,b,c,d]			1990 Pu pCi/g[a,b,c,d]			1991 Pu pCi/g[a,b,c,d]		
1-018	0.10	±	0.01	0.08	±	0.01	0.07	±	0.02	0.13	±	0.02
1-036	0.88	±	0.01	0.08	±	0.01	0.07	±	0.001	0.25	±	0.05
1-054	0.03	±	0.01	0.13	±	0.02	0.04	±	0.01	0.06	±	0.01
1-072	0.37	±	0.04	0.16	±	0.02	0.21	±	0.03	0.18	±	0.03
1-090	10.6	±	0.98	2.52	±	0.27	2.18	±	0.21	1.49	±	0.23
1-108	10.4	±	0.94	8.56	±	0.81	9.14	±	0.12	9.76	±	1.35
1-126	1.55	±	0.14	1.08	±	0.13	1.46	±	0.17	2.13	±	0.32
1-144	0.20	±	0.02	0.12	±	0.01	0.17	±	0.02	0.19	±	0.03
1-162	0.09	±	0.01	0.06	±	0.01	0.06	±	0.01	0.09	±	0.02
1-180	0.06	±	0.01	0.08	±	0.01	0.04	±	0.001	0.04	±	0.01
1-198	0.10	±	0.01	0.05	±	0.01	0.13	±	0.005	0.17	±	0.04
1-216	0.05	±	0.01	0.05	±	0.01	0.05	±	0.007	0.05	±	0.02
1-234	0.05	±	0.01	0.05	±	0.01	0.03	±	0.007	0.05	±	0.01
1-252	0.09	±	0.01	0.08	±	0.01	0.07	±	0.01	0.09	±	0.02
1-270	0.07	±	0.01	0.06	±	0.01	0.05	±	0.01	0.08	±	0.02
1-288	0.03	±	0.01	0.06	±	0.01	0.07	±	0.01	0.09	±	0.02
1-306	0.12	±	0.01	0.10	±	0.01	0.08	±	0.01	0.09	±	0.02
1-324	0.16	±	0.02	0.07	±	0.01	0.09	±	0.01	0.14	±	0.03
1-342	0.02	±	0.01	0.04	±	0.01	0.05	±	0.008	0.05	±	0.02
1-360	0.12	±	0.02	0.08	±	0.01	0.11	±	0.01	0.1	±	0.02

Outer Circle:

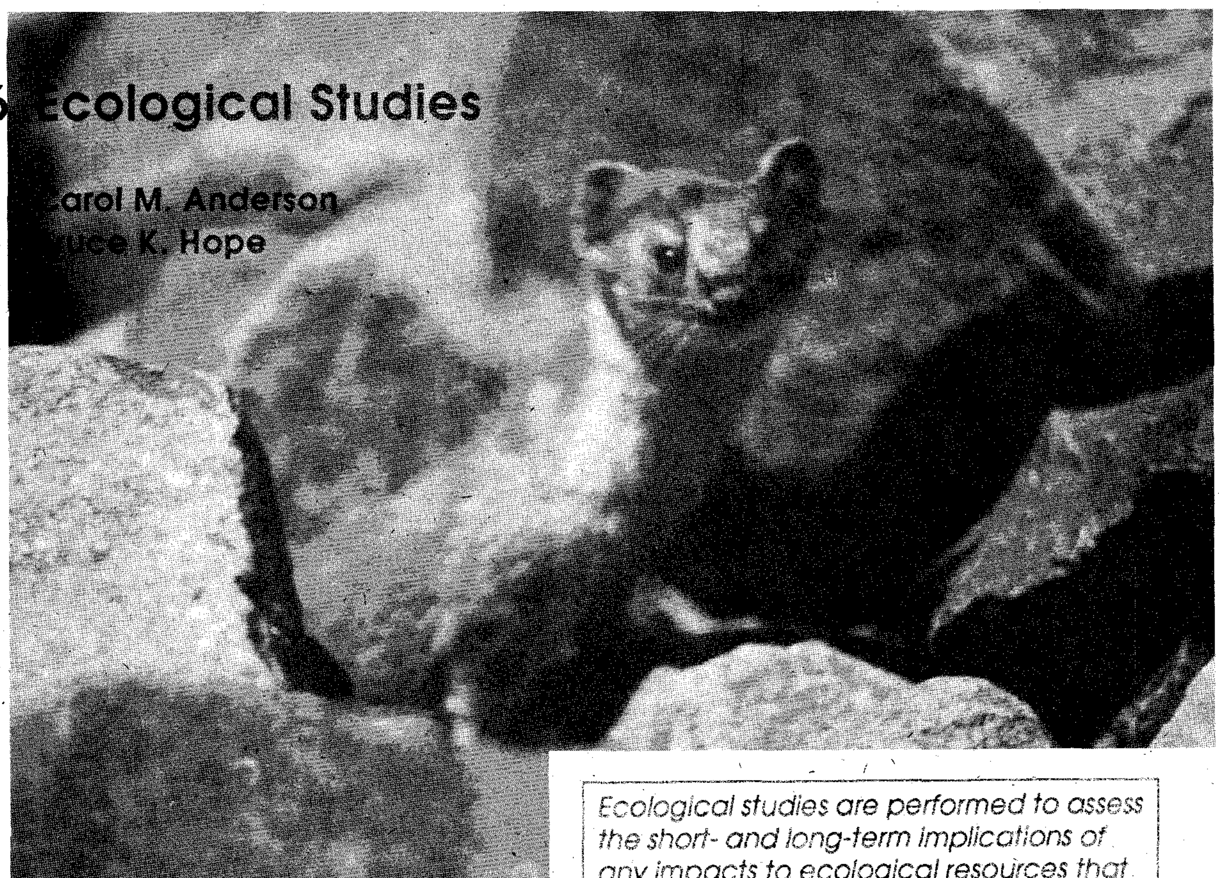
Location	1988 Pu pCi/g[a,b,c,d]			1989 Pu pCi/g[a,b,c,d]			1990 Pu pCi/g[a,b,c,d]			1991 Pu pCi/g[a,b,c,d]		
2-018	0.02	±	0.00	0.02	±	0.01	0.00	±	0.003	0.01	±	0.00
2-036	0.07	±	0.01	0.04	±	0.01	0.05	±	0.01	0.06	±	0.01
2-154	0.03	±	0.01	0.06	±	0.01	0.18	±	0.03	0.07	±	0.01
2-072	0.11	±	0.01	0.46	±	0.06	0.14	±	0.02	0.14	±	0.02
2-090	7.12	±	0.67	1.94	±	0.23	3.94	±	0.5	3.61	±	0.45
2-108	0.47	±	0.05	0.53	±	0.06	0.32	±	0.04	0.06	±	0.07
2-126	0.03	±	0.01	0.28	±	0.04	0.20	±	0.02	0.25	±	0.05
2-144	0.35	±	0.03	0.03	±	0.01	0.02	±	0.005	0.04	±	0.00
2-162	0.02	±	0.01	0.02	±	0.01	0.01	±	0.004	0.03	±	0.00
2-180	0.03	±	0.01	0.08	±	0.01	0.03	±	0.007	0.05	±	0.01
2-198	0.10	±	0.01	0.01	±	0.01	0.05	±	0.01	0.07	±	0.01
2-216	0.07	±	0.01	0.07	±	0.01	0.04	±	0.007	0.05	±	0.01
2-234	0.03	±	0.01	0.05	±	0.01	0.04	±	0.002	0.04	±	0.01
2-252	0.04	±	0.01	0.04	±	0.01	0.04	±	0.007	0.04	±	0.01
2-270	0.06	±	0.01	0.06	±	0.01	0.04	±	0.007	0.03	±	0.01
2-288	0.07	±	0.01	0.08	±	0.01	0.03	±	0.006	0.03	±	0.00
2-306	0.02	±	0.00	0.04	±	0.01	0.06	±	0.01	0.08	±	0.01
2-324	0.14	±	0.02	0.06	±	0.01	0.09	±	0.01	0.08	±	0.01
2-342	0.10	±	0.01	0.06	±	0.01	0.10	±	0.01	0.1	±	0.01
2-360	0.05	±	0.01	0.04	±	0.01	0.06	±	0.01	0.02	±	0.00

a. Not blank corrected.
b. Samples to a depth of 5 cm.
c. Concentrations are for the fraction of soil measuring less than 2 mm diameter.
d. Error term represents two standard deviations.

observed variability. Other investigators (PI80) have observed high variability in soil plutonium concentrations in other contaminated sites, especially near the release source. Investigators ascribed these variations in plutonium-239, -240 to varying distances from the point of release (75 percent), microtopographical variations (20 percent), and sampling error, which included subsampling and analytical error (5 percent). Variability in plutonium concentrations in soils taken from the two radial grids at 18° to 36° and 162° to 360° was extremely small.

3.6 Ecological Studies

Carol M. Anderson
Bruce K. Hope



Ecological studies are performed to assess the short- and long-term implications of any impacts to ecological resources that may have occurred at the Rocky Flats Plant as a result of past operations. Ecological studies also are performed to ensure compliance with all applicable biological regulations. Pictured is a long-tailed weasel, one of the small mammals found within plant boundaries. A detailed description of current and future ecological studies is provided in the following pages.

OVERVIEW

Ecological studies are an ongoing part of RFP routine operations. These studies focus on the presence, abundance, and spatial distribution of plant and animal life (biota) at the RFP and are fundamental in identifying the impacts of the plant relative to NEPA and other state and federal regulations and guidelines. Specialized studies, including floodplain identification and radioecological studies, investigate the unique ecological aspects of the RFP.

The last comprehensive study of the environment at the RFP was conducted for the *Environmental Impact Statement, Rocky Flats Plant Site* (DOE80). Much of the information contained in that document was compiled before September 1977. As noted in the *Draft Environmental Analysis Report* (EG90a), more recent information is available on land use, wetlands, and other environmental elements. Current information on specific natural resources at RFP results from studies including *Wetland Assessment, Rocky Flats Site* (EG90b), and *Threatened and Endangered Species Evaluation, Rocky Flats Plantsite* (EG91i). The scope of the current ecological studies program has been determined by public demand for current information on RFP impacts and increased emphasis on requirements for NEPA pursuant to Secretary of Energy Notice #15-90.

ECOLOGICAL MONITORING

To meet a growing priority for comprehensive, long-term ecological information concerning the plantsite, design and implementation of formalized ecological monitoring will be initiated in 1992. Primary goals for the Ecological Monitoring Program (EcMP) will be to (1) thoroughly assess trends in terrestrial and aquatic biological media, (2) demonstrate compliance with applicable federal, state, and local biological regulations, (3) confirm adherence to ecological aspects of DOE environmental protection policies, and (4) support cost-effective environmental management decisions. This program is currently in the detailed design phase, with a comprehensive program plan due to DOE in October 1992.

RESOURCE PROTECTION

The Resource Protection Program (RPP) will conduct biological surveys and assessments to ensure compliance with biological regulations (Endangered Species Act, Fish and Wildlife Coordination Act, Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, Colorado State Species of Concern) for OUs and sitewide projects (DOE91e, DOE91f).

ECOLOGICAL STUDIES

The following ecological studies were underway in 1991.

- Baseline Studies - inventories of aquatic and terrestrial wildlife and vegetation to establish baseline ecological conditions.
- Radioecological Investigations - studies of deer, small mammals, soils, and vegetation to evaluate various population parameters and radionuclide uptake in these populations, and to establish remediation standards.
- Environmental Evaluations - investigations to assess actual or potential effects that contamination at hazardous waste sites may have on plants and animals.

BASELINE STUDIES

Baseline studies serve as a snapshot in time of the wildlife and vegetation resources at RFP. Information gathered on the presence, abundance, and distribution of aquatic and terrestrial vegetation and wildlife is used to measure the impacts of various intrusive activities on these natural resources and to comply with the NEPA *Code of Federal Regulations*, 40 CFR Parts 1500-1508, 10 CFR Part 1021, and DOE Order 5440.1D, "National Environmental Policy Act Compliance Program." Baseline studies began in November 1990 and concluded in early 1992. The final baseline wildlife/vegetation survey report, which will contain all the data gathered during the course of these investigations, will be available in August 1992, and will cover three major investigative categories: aquatics, terrestrial vegetation, and terrestrial wildlife. Highlights of the forthcoming report are given below.

Aquatics

Seven species of fish including the white sucker *(Catostomus commersoni)*, green sunfish *(Lepomis cyanellus)*, and largemouth bass *(Micropterus salmoides)* (DOE91b), were documented as being present in the Woman Creek and Rock Creek drainages. Each of these seven species was listed as common in occurrence. Two other previously recorded species, the bluegill *(Lepomis macrochirus)* and rainbow trout *(Salmo gairdneri)*, were not encountered but may be located once sampling is completed in the Walnut Creek drainage system.

Terrestrial Vegetation

Baseline studies documented and/or confirmed the presence of 362 species of plants on the RFP (DOE91b). This is an increase of 78 species over the previously reported vegetation inventory (DOE80).

Terrestrial Wildlife

Preliminary findings included six species of amphibians and eight species of reptiles (DOE91b). All species previously reported were confirmed and seven species new to the site were recorded. As of July, 1990, 144 bird species were reported (DOE91b), a significant increase over the 38 species previously reported (DOE80). Thirty-five species were confirmed to nest at the RFP and an additional 44 were characterized as possible or occasional breeding species. Twenty-three species of mammals were documented including an uncommon finding of a water shrew at a lower elevation than previously recorded in Colorado. Of the 18 previously recorded species, only the silky pocket mouse *(Perognathus flavus)* has not yet been confirmed (DOE91b).

RADIOECOLOGICAL INVESTIGATIONS

Deer

Deer ecology investigations assess the habitat use, population size, and radionuclide uptake by mule deer populations at RFP. In addition to supporting NEPA requirements, these investigations are needed to evaluate and lessen the impacts of plant operations from remedial actions and alternative uses of the buffer zone. Investigations began in 1991 and will continue through 1994.

Preliminary results suggest that deer use the Solid Waste Management Unit (SWMU) areas at RFP, but do not assimilate significant amounts of plutonium, uranium, or americium (CSU92c).

Small Mammals, Vegetation, and Soil

Radioecological investigations of small animals, vegetation, and soil are designed to (1) assess standards for remediation of plutonium and americium contamination in soils east of the 903 Pad at the RFP, (2) evaluate the current distribution of plutonium, americium, and other radionuclides in the terrestrial environment near the 903 Pad, and (3) compare the present distribution of plutonium with that measured in the mid-1970s. A description and characterization of radionuclides in the biota is needed to support NEPA activities, IAG actions, and future decisions concerning environmental remediation under RCRA and CERCLA.

Preliminary results indicate that mean plutonium concentrations in the vegetation have decreased from 1,056 Becquerels per kilogram (Bq/kg) reported for the 1972-1974 period (LI76) to 164 Bq/kg in 1989 (CSU92b), amounting to a decrease of approximately 84 percent. Likewise, plutonium accumulations in the soil showed a general decline from the 1972-1974 period (LI76) to 1989 (CSU92b). Total inventory of plutonium in the soil and vegetation of the primary study area was estimated to be 463 kiloBecquerels per square meter (kBq/m^2) in 1989 (CSU92b), approximately 20 percent of the plutonium inventory reported for the 1972-1974 period (LI76). No significant difference between small mammal tissue samples analyzed 18 years ago and samples collected for this study were found (CSU92a). This reconfirms findings in the earlier studies that small mammals are not assimilating plutonium or americium; therefore, the small mammal studies have been discontinued. These vegetation and soil studies will be discontinued at the end of FY93, and a comprehensive report containing all of the data and conclusions generated by these studies will be prepared by October 1993.

ENVIRONMENTAL EVALUATIONS

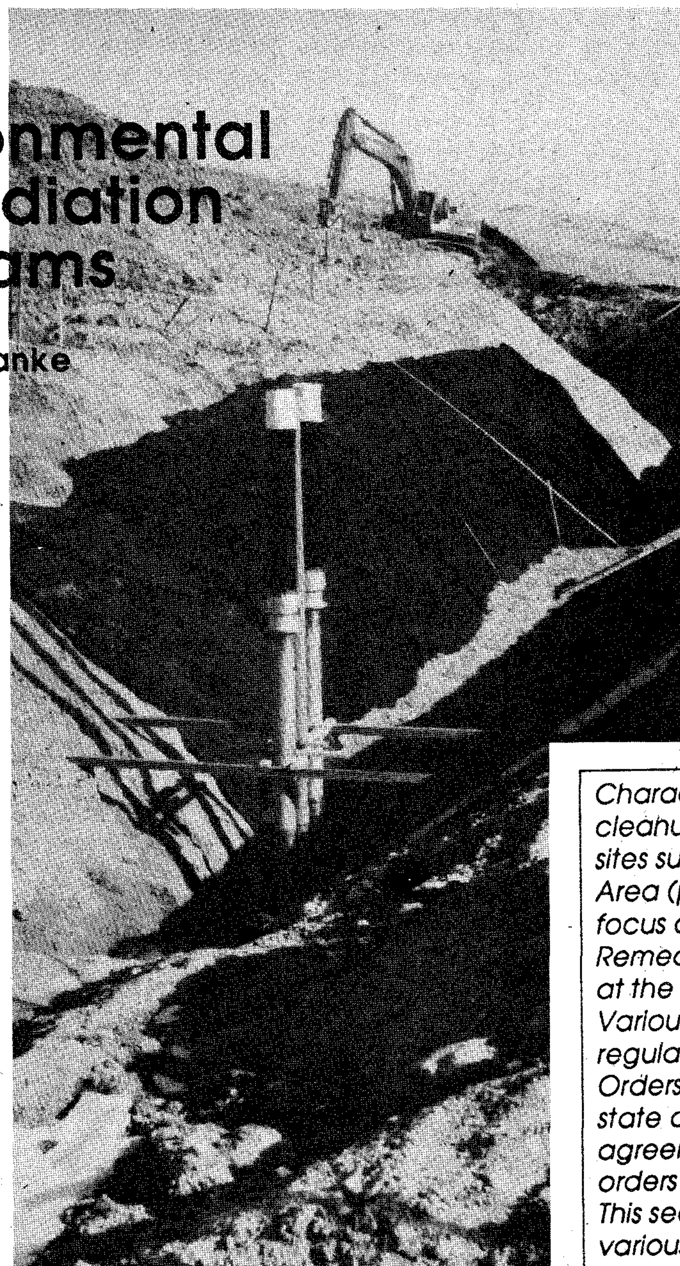
An Environmental Evaluation (EE) is an assessment of actual or potential effects of contamination at hazardous waste sites on plants and animals other than people or domesticated species. Ecological assessments of hazardous waste sites are an essential element in determining overall risk and protecting public health, welfare, and the environment.

Hazardous waste site EEs are intended to provide decision makers with information on risks to the natural environment that are associated with contaminants or with actions designed to remediate the site. The EE provides information to determine whether the ecosystem has been, or has the potential to be, damaged by hazardous substances and/or wastes released into IHSSs defined under the IAG. Under the IAG, the IHSSs and SWMUs have been grouped into 16 OUs. Information from the EEs assists in determining the form, feasibility, and extent of remediation necessary for the RFP in accordance with applicable state and federal regulations. The development of a standardized ecosystem approach and development of individual OU-specific EE work plans provide focused investigations of potential contamination effects on the biota of the RFP and the surrounding area. Results of the studies are presented in the EE reports submitted as a chapter of the RCRA Facility Investigations/Remedial Investigations (RFI/RI) Report for each OU.

Field sampling in OU 1 was completed in 1991 and is ongoing in OUs 2 and 5. Field sampling has not begun for the rest of the OUs. Initial findings have tripled the number of plants and animals on the species list for RFP. The entire buffer zone, particularly Woman Creek, has been characterized as ecologically diverse and rich in habitat. Three different physiographic regions (intermontaine, high plains, and tall grass) overlap at RFP and attract species coming down from the mountains and up from the plains. The draft OU 1 EE report was produced in June 1992; the final version of this report, containing all the data gathered at OU 1, will be available in October 1992.

4. Environmental Remediation Programs

Jeffrey E. Janke



Characterization and cleanup of inactive waste sites such as the 881 Hillside Area (pictured) are the focus of Environmental Remediation (ER) Programs at the Rocky Flats Plant. Various environmental laws, regulations, Executive Orders, DOE Orders, and state and federal facility agreements and consent orders apply to ER activities. This section describes the various Operable Units identified at Rocky Flats and the status of remediation activities in those areas.

OVERVIEW

Environmental Remediation (ER) Programs were established to comply with regulations for characterization and cleanup of inactive waste sites at RFP. The program specifically includes inactive site identification and characterization, remedial design and cleanup action, and post-closure activities of inactive radioactive-, hazardous-, and mixed-waste sites. The ER Program is designed to investigate and clean up contaminated sites. The primary objective of the Remedial Action Program is to bring all known waste sites at RFP into compliance with applicable federal, state, and local environmental laws and regulations, and at the same time ensure that risks to human health and the environment are either reduced to prescribed levels or eliminated.

Various environmental laws, regulations, Executive Orders, DOE Orders, and state and federal facility agreements and consent orders apply to ER programs. DOE has negotiated several agreements (with the EPA and CDH), which address compliance with environmental regulations, scopes of work, and timetables that require DOE compliance. DOE, CDH, and the EPA signed the IAG in January 1991, which sets forth schedules and budgets for ER. EPA's Land Disposal Restrictions (LDRs) have been addressed by an FFCA. The AIP between DOE and the State of Colorado requires the acceleration of cleanup activities where contamination presents a potential threat to health or the environment, and additional monitoring requirements.

The IAG and its attachments address details on specific response requirements that must be met during the CERCLA and the RCRA processes being employed for assessment and remediation of identified IHSSs on or adjacent to the RFP. These 178 IHSSs have been categorized into 16 OUs based on cleanup priorities, waste type, and geographic location (Table 4-1). The IAG Statement of Work (SOW) provides details on the activities that must occur and the sequence of those activities to satisfy the requirements of the IAG. Increased levels of security imposed on all DOE weapons facilities because of the Desert Storm activities in the Persian Gulf slowed progress on many RFP IAG activities in January and February 1991.

The following sections describe the 16 OUs and address the activities conducted therein during 1991. Individual maps of all OUs are located at the end of this section.

Table 4-1
Organization of Individual Hazardous Substance Sites (IHSSs) into Operable Units (OUs)

Operable Unit #	Individual Hazardous Substance Sites
1	102, 103, 104, 105.1, 105.2, 106, 107, 119.1, 119.2, 130, 145
2	108, 109, 110, 111.1, 111.2, 111.3, 111.4, 111.5, 111.6, 111.7, 111.8, 112, 113, 140, 153, 154, 155, 183, 216.2, 216.3
3	199, 200, 201, 202
4	101
5	115, 133.1, 133.2, 133.3, 133.4, 133.5, 133.6, 142.10, 142.11, 209
6	141, 142.1, 142.2, 142.3, 142.4, 142.5, 142.6, 142.7, 142.8, 142.9, 142.12, 143, 156.2, 165, 166.1, 166.2, 166.3, 167.1, 167.2, 167.3, 216.1
7	114, 203
8	118.1, 118.2, 123.1, 135, 137, 138, 139.1, 139.2, 144, 150.1, 150.2, 150.3, 150.4, 150.5, 150.6, 150.7, 150.8, 151, 163.1, 163.2, 172, 173, 184, 188
9	121, 122, 123.2, 124.1, 124.2, 124.3, 125, 126.1, 126.2, 127, 132, 146.1, 146.2, 146.3, 146.4, 146.5, 146.6, 147.1, 149, 159, 215
10	129, 170, 174, 175, 176, 177, 181, 182, 205, 206, 207, 208, 210, 213, 214
11	168
12	116.1, 116.2, 120.1, 120.2, 136.1, 136.2, 147.2, 157.2, 187, 189
13	117.1, 117.2, 117.3, 128, 134, 148, 152, 157.1, 158, 169, 171, 186, 190, 191
14	131, 156.1, 160, 161, 162, 164.1, 164.2, 164.3
15	178, 179, 180, 204, 211, 212, 217
16	185, 192, 193, 194, 195, 196, 197

OU 1 - 881 HILLSIDE ASSESSMENT/REMEDIATION

OU Description

The alluvial groundwater at the 881 Hillside Area, located north of Woman Creek in the southeast section of RFP, was contaminated in the 1960s and 1970s with solvents and radionuclides. The area is almost 2 miles from the eastern, outer edge of the plant's buffer zone at Indiana Street. The various IHSSs that make up OU 1 are being investigated and treated as high-priority sites because of elevated concentrations of organic compounds in the near-surface groundwater and the proximity of the contamination to a drainage system leading to an offsite drinking water supply. The selected Interim Remedial Action (IRA) at OU 1 involves construction of an underground drainage system called a French drain that will intercept and contain contaminated groundwater flowing from the OU 1 area. The contaminated water will be treated at the 891 treatment facility, designed for this purpose, and released onsite into the South Interceptor Ditch alongside Woman Creek. IRA construction is scheduled to be completed in 1992. The Remedial Investigation and Feasibility Study (RI/FS) to determine the final remedial action are continuing in parallel with the IRA.

Phase III RCRA Facility Investigation/Remedial Investigation (RFI/RI). Work permitting, mobilization scheduling, and drill hole prioritizing began in early spring. The Final Work Plan for the Phase III RFI/RI was submitted to EPA and CDH in April. Packer tests were started in November 1991 in the deeper boreholes, and downhole geophysics was used to support the packer tests. Additional sampling included some manhole and sump sampling around Building 881. Hydraulic testing consisted of a step drawdown test followed by evaluation of tracer dyes used to determine the movement of contaminants through the ground.

IRA Phase IIA, I-B II-B. Phase I-B IRA construction, which included construction of the 891 treatment building, placement of the influent storage tank foundation, and tank installation, was completed in May. All four 16,000-gallon influent tanks were set into place on the containment pad, and systems operations testing began. Phase II-A construction, which included installation of the process treatment system and effluent storage tanks, started in July. Acid and caustic tanks for the 891 treatment building were received in October. Pipe installation was 95 percent complete, and pipe heat tracing and insulation was approximately 90 percent complete by December. Construction of the three 160,000-gallon effluent tanks has been completed.

IRA Phase II-B French drain excavation began in November. Excavation activities started with the sump pit at the east end of the French drain.

RI-Environmental Evaluation (EE). The OU 1 RI field sampling program began with biota sampling and borehole staking. Small mammal trapping, vegetation sampling, aquatic invertebrate, and fish and minnow sampling were completed in the fall. Tissue samples were taken of small mammals, fish, salamanders, minnows, crayfish, and numerous plant species. Ecological community survey field activities were also completed, and analysis of the ecological community survey data began.

OU 2 - 903 PAD, MOUND, AND EAST TRENCHES ASSESSMENT/REMEDIATION

OU Description

Contamination at the 903 Pad and Mound areas is largely attributed to the storage in the 1950s and 1960s of waste drums that corroded over time, allowing hazardous and radioactive material to leak into the surrounding soil. Additional contamination may have resulted from wind dispersion during drum removal and soil movement activities. The East Trenches Area was used for disposal of plutonium- and uranium-contaminated waste and sanitary sewage sludge from 1954 to 1968. Two areas adjacent to the trenches were used for spray irrigation of STP effluent, some of which may have contaminants that were not removed by the treatment system.

An Interim Measures/Interim Remedial Action (IM/IRA) provides for surface water in source areas of contamination to be collected, treated, and discharged to the surface water drainage. Operation of a field-scale treatability unit for the South Walnut Creek drainage began in May 1991. The effectiveness of the treatment process will be evaluated at three locations: the entrance to the treatment facility, several points within the facility, and the discharge point. After completion of the field-scale treatability tests, the unit is anticipated to remain in service until the final remedial action is operational.

A second IM/IRA was established in late 1991. This Proposed Subsurface Investigation IM/IRAP/EA will be conducted on an area located north of Woman Creek that encompasses the 903 Pad, the Mound Area, and the East Trenches Area of OU 2. This interim action will identify and evaluate IRAs for removal of residual free-phase VOC contamination from three distinct subsurface environments at OU 2. Each of the proposed VOC-removal actions involve *in situ*, vacuum-enhanced vapor extraction technology. The IRAs are proposed for the collection of information that will aid in the selection and design of final remedial actions that address subsurface, residual free-phase VOC contamination at OU 2.

Phase II RFI/RI. The Phase II RFI/RI Work Plan (Alluvial) was revised and subsequently approved by EPA and CDH in the fall of 1991. The Final Phase II RFI/RI Work Plan (Bedrock) was delivered to EPA and CDH in July.

Preliminary activities for the Phase II RFI/RI (Alluvial) fieldwork began in March with preparation of an Environmental Management Construction Yard Master Plan. The construction yard is used to store equipment, locate construction trailers, and provide logistic support for field activities. OU 2 RI fieldwork began in May with the location of boreholes, staking and surveying, decontamination pad operational readiness, and safety training.

IRA. An agreement among DOE, EPA, and CDH was made to divide the OU 2 - 903 Pad, Mound, and East Trenches IRA into two phases. One phase will collect and treat water from the South Walnut Creek drainage; the other phase will do the same for the Woman Creek drainage.

The granular activated carbon (GAC) treatment facilities were installed in May and became operational in early June. The GAC IRA treatment system collected, treated, and discharged 4,822,503 gallons of surface water during 1991.

IM/IRA. The draft Woman Creek Interim Measures/Interim Remedial Action/Environmental Assessment (IM/IRA/EA) Plan recommending "no action" was submitted to EPA and CDH in October and was subsequently rejected. Issues included hydrogeologic and source characterization and testing of *in situ* vapor extraction contributing to the cleanup of the three OU 2 contaminated areas. DOE presented major changes to the scope of a revised IM/IRA Plan consistent with agencies' requirements. Construction of a radionuclide removal system, which will be integrated with the GAC system, is scheduled for the spring of 1992.

EE. Small mammals, vegetation, periphyton, benthic macroinvertebrates, and insects were sampled as part of the OU 2 EE program. Tissue samples were also collected from small mammals, vegetation, and insects. Tissue samples were sent to the laboratories, and data analysis of the ecological community survey data began.

OU 3 - OFFSITE AREA ASSESSMENT

OU Description

OU 3 remedial activities are divided into two main categories. In the first category, the IAG directs activities according to CERCLA. This involves assessment of contamination in offsite IHSSs. The second category responds to a 1985 settlement agreement among

DOE, The Dow Chemical Company, Rockwell International, local governments, and private landowners. This Settlement Agreement requires remediation actions to reduce plutonium contamination on areas adjacent to the eastern boundary of RFP. Remedial activities in compliance with the settlement agreement (deep disc plowing) began in 1985. The disturbance resulting from remediation is being revegetated with mediocre success. The overall schedule for this activity is determined by the year-to-year success of the revegetation effort and requirements of the landowners. Figure 4-3 shows the IHSSs that constitute OU 3.

Past Remedy Report. The final Past Remedy Report was delivered to EPA and CDH in April. This report details the history of the remedy ordered by the U.S. District Court pursuant to the Settlement Agreement, the implementation of the remedy, and the effectiveness of the remedy. The report includes a health assessment identifying the public health risk associated with potential exposure to the public before the start of site remediation, during remediation, and after completion of the Settlement Agreement imposed remedy. The report summarizes results of plutonium and americium analyses of soil samples and current revegetative activities.

Historical Information Summary. The Final Historical Information Summary and Preliminary Health Risk Assessment Report was delivered to EPA and CDH in April. This report provides known data describing contamination within three offsite reservoirs: Great Western Reservoir, Standley Lake Reservoir, and Mower Reservoir. The report also includes a health risk assessment identifying the public health risk associated with potential exposure to the public for a no-action alternative for remediation of the contamination.

Offsite Areas RFI/RI. Draft and Final Offsite Areas RFI/RI Work Plans were delivered to EPA and CDH in July and December, respectively. The final work plan was modified to incorporate comments regarding (1) the contaminants of concern to be sampled, and (2) the statistical basis for the number of samples taken. The revised plan was designed to obtain sufficient samples to validate older studies based on sound justification for the number of sampling locations in each geographical location and environmental media.

A presentation on the OU 3 Offsite Areas was made to the Technical Review Group (TRG) in July. The TRG provides early community involvement in environmental restoration projects through participation in work plan scoping and draft work plan review. The group is comprised of approximately 20 participants from local municipalities and citizen groups.

A wind tunnel is being considered to evaluate potential resuspension of soils and sediments contributing to offsite health risk. The Preliminary Risk Assessment in OU 3 indicated inhalation of resuspended particles as the major pathway for offsite health risk. The wind tunnel would be used to develop data that measures the resuspension of soils and sediments, and thus, the contribution from wind-dispersed radiological contamination.

OU 4 - SOLAR PONDS ASSESSMENT

OU Description

OU 4 is comprised of five solar evaporation ponds: 207A, 207B series (north, center, south), and 207C. Beginning in the late 1950s and continuing until 1983, the ponds were used to store and evaporate low-level radioactive process water containing high concentrations of nitrates and treated acidic wastes. The sludge and sediments that resulted from the process were periodically removed and disposed at the Nevada Test Site.

As technology improved through the 1960s and 1970s, the ponds were relined with various upgraded materials; however, leakage from the ponds into the soil and groundwater was detected. Interceptor trenches were installed in 1971 to collect and recycle groundwater contaminated by the ponds and to prevent natural seepage and pond leakage from entering North Walnut Creek. In 1981 these trenches were replaced by the current and larger interceptor trench system, which recycles approximately 4 million gallons of groundwater a year back into the solar evaporation ponds. Presently, only the 207B north solar evaporation pond receives contaminated groundwater collected by the interceptor system.

The ponds are RCRA interim status regulated units that are currently under closure. To proceed with remedial measures and characterize the level of contamination at the site, approximately 8 million gallons of excess liquid in the ponds must be removed. The removal of this liquid and the redirection and treatment of the groundwater by the interceptor trench system are the focus of the IRA that is scheduled for operation in early 1992.

DOE's proposed cleanup action involves an initial partial closure of the ponds to eliminate the flow of harmful contaminants into groundwater and soil. The method of action calls for evaporation of the pond water (estimated at approximately 12 million gallons) and sludge removal. Sludge removed from the ponds and solidified with Portland cement (referred to as "pondcrete") will be transported to the Nevada Test Site.

The ponds will be dewatered by natural evaporation, enhanced natural evaporation, and forced evaporation. Enhanced evaporation will be achieved by (1) adding a nontoxic dye to the water to promote increased solar heat absorption, and (2) using heater/soaker pipes, which increase the surface area for evaporation. Forced evaporation will be achieved by using an existing evaporation system and portable evaporator units. The forced evaporation method will be used predominantly for water from precipitation collected by the interceptor system.

1991 Activity

The Final Phase I RFI/RI Work Plan was delivered to EPA and CDH in November. Comments received from CDH conveyed their belief that the closure activities, specifically the operation of the "surge tanks" for the interceptor trench pump house system, constitute an interim measure study under the IAG, and therefore, the procedures dictated by the IAG for public notice and comment must be followed. CDH requested an IM/IRA Action Plan for the surge tanks and flash evaporators, which would be used to treat groundwater collected from the area adjacent to the Solar Evaporation Ponds. The draft final IM/IRA was delivered to the EPA and the CDH in August and was subsequently released for public comment. CDH gave conditional approval of the IM/IRA Plan. Work is underway to review and address both public and regulatory agency comments and prepare a Responsiveness Summary to be included in the Final IM/IRA document.

OU 5 - WOMAN CREEK ASSESSMENT

OU Description

OU 5 consists of several IHSSs within the Woman Creek drainage. These IHSSs include retention ponds C-1 and C-2. Two additional surface disturbances have been identified, one located south of IHSSs 133.1 - 1.33.4 and one located west of IHSS 209. These last two sites have been included in the OU 5 Work Plan.

1991 Activity

The Final Phase I RFI/RI Work Plan was submitted to EPA and CDH in August. The RFI/RI investigates and defines the site physical characteristics, defines the sources of contamination, and describes the nature and extent of contamination. EPA and CDH disapproved the work plan believing that if the plan was implemented it would provide insufficient information on which to base a risk assessment and remedial action decisions. A geophysical survey, conceptual model, and the incorporation of Smart Creek/Ditch were added to the work plan, which was resubmitted to EPA and CDH in December. The EE program for OU 5 continued in 1991 and included sampling of vegetation, small mammals, periphyton, benthic macroinvertebrates, insects, and tissue collections.

OU 6 - WALNUT CREEK ASSESSMENT

OU Description

OU 6 consists of IHSSs within the Walnut Creek drainage. Thirteen additional groundwater monitoring wells will be installed throughout OU 6 to monitor the alluvial aquifer. Five bedrock groundwater monitoring wells will be installed in the vicinity of North Walnut Creek to characterize the bedrock aquifer, and nine additional bedrock groundwater monitoring wells may be installed in the vicinity of the A-series ponds.

Sediment samples are proposed to be taken along each stream segment on North and South Walnut Creeks where existing data are insufficient to adequately characterize the sediments. Elsewhere within the OU 6 drainage, there is sufficient information about the sediments leading to a reduction in the number of sampling locations. Surface-soil sampling has been modified for the Triangle Area (IHSS 165) and the Old Outfall Area (IHSS 143) to enable sampling of the original surface area by borings through the overlying fill.

1991 Activity

Draft and Final Phase I RFI/RI Work Plans were submitted to EPA and CDH in April and September, respectively. EPA and CDH disapproved the Final Phase I RFI/RI Work Plan for OU 6 in October. A conceptual model and field sampling changes were added and the revised work plan was approved in February 1992.

OU 7 - PRESENT LANDFILL

OU Description

The Present Landfill, OU 7, is located north of the plant complex on the western edge of an unnamed tributary of North Walnut Creek and is comprised of two IHSSs. IHSS 114 includes landfill waste and leachate at the Present Landfill, soils beneath the landfill potentially contaminated with leachate, and sediments and water in the East Landfill Pond. IHSS 203 contains potentially contaminated soils at the Inactive Hazardous Waste Storage Area. The Present Landfill began operation in August 1968 and was originally constructed to provide for disposal of RFP's nonradioactive and nonhazardous wastes. In September 1973, tritium was detected in leachate from the landfill. During the mid-1980s, extensive investigations were conducted on the waste streams being disposed into the landfill; consequently, hazardous wastes and hazardous constituents were identified. Although currently operating as a nonhazardous sanitary landfill, the facility is considered to be an inactive hazardous waste disposal unit undergoing RCRA closure.

1991 Activity

The Draft Final Phase I RFI/RI Work Plan was submitted to EPA and CDH in August and was conditionally approved by these agencies in October. The plan was revised to address agency comments and resubmitted in December. RFI/RI fieldwork was deferred to FY93 (October 1992) because of funding limitations.

OU 8 - 700 AREA ASSESSMENT

OU Description

OU 8 consists of IHSSs inside and around the production areas of the RFP. Contamination sources within the various IHSSs include above ground and underground tanks, equipment washing areas, and releases inside buildings that potentially affected areas outside the buildings. Contaminants from these sources may have been introduced into the environment through spills on the ground surface, underground leakage and infiltration, and in some cases, through precipitation runoff. The chemical composition of the contaminants also varies widely among the IHSSs, ranging from low-level radioactive mixed wastes to nonradioactive organic and inorganic compounds. No activities are scheduled for OU 8 until 1992.

OU 9 - ORIGINAL PROCESS WASTE LINES ASSESSMENT

The Original Process Waste Lines (OPWL), OU 9, consists of a system of 57 designated pipe sections extending between 73 tanks and 24 buildings connected by 35,000 feet of buried pipeline that transferred process wastes from point of origin to onsite treatment plants.

The system was placed into operation in 1952, and additions were made to the system through 1975. The original system was replaced over the 1975-1983 period by the new process waste system. Some tanks and lines from the original system have been incorporated into either the new process waste system or the fire water deluge collection system.

The original system is known to have transported or stored various aqueous process wastes containing low-level radioactive materials, nitrates, caustics, and acids. Small quantities of other liquids were also introduced into the system, including pickling liquor from foundry operations, medical decontamination fluids, miscellaneous laboratory liquids from Building 123, and laundry effluent from Buildings 730 and 778. The RFI/RI plan includes inspection and sampling of the OPWL tanks and pipelines that are accessible and soil sampling to determine the extent of contamination in the vadose zone. The soil sampling will be performed by installing test pits and borings where known or suspected releases occurred, near pipe joints and valves, at approximately 200-foot intervals along the pipelines, and by installing borings around the outdoor tanks. Soil characterization studies will determine the need for soil removal and/or treatment. The results of the RFI/RI will determine the need for interim and/or final remediation action.

Draft and Final Phase I RFI/RI Work Plans were submitted to EPA and CDH in June 1990 and November 1991, respectively. Agency approval of the work plan is pending.

OU 10 - OTHER OUTSIDE CLOSURES ASSESSMENT

OU 10 is comprised of IHSSs scattered throughout the plant and various hazardous waste units. Five of the IHSSs are located in the Protected Area (PA), two are located in the buffer zone near the Present Landfill, and the remaining are located near various buildings throughout the plant. The types of wastes identified at these sites range from pondcrete/ saltcrete storage and drum storage, to a utilization yard with waste spills. The primary components of the RFI/RI Work Plan for OU 10 are a Field Sampling Plan (FSP), Baseline Risk

Assessment Plan (BRAP), and an EE Work Plan. IRA is scheduled to begin in early 1998. The Draft Phase I RFI/RI Work Plan for OU 10 was submitted to EPA and CDH in November. Comments were received and the work plan is being revised to address these comments.

OU 11 - WEST SPRAY FIELD ASSESSMENT

The West Spray Field is located within RFP property boundary immediately west of the main facilities area. The West Spray Field was in operation from April 1982 to October 1985. During operation, excess liquids from the solar evaporation ponds 207-B North and Center (contaminated groundwater in the vicinity of the ponds and treated sanitary sewage effluent) were pumped periodically to the West Spray Field for spray application. The spray field boundary covers an area of approximately 105.1 acres, of which 38.3 acres received direct application of hazardous waste. The RFI/RI process will entail field studies to determine the presence and levels of hazardous constituents in soil and groundwater. Draft and Final RFI/RI Work Plans were submitted to EPA and CDH in 1990 and January 1992, respectively.

OU 12 THROUGH OU 16

These OUs consist of lower priority areas for which various remedial activities are scheduled in 1992.

OU 12 - 400/800 Area Assessment. Contamination in these OU 12 areas originates from cooling tower ponds, chemicals from fiberglass operations, leaks, and spills that may have contaminated the soils with VOCs and other organics, metals, and acids.

OU 13 - 100 Area Assessment. OU 13 comprises chemical storage areas, an underground tank, waste destruction areas, a valve vault, and places where minor leaks or spills occurred. The soil has received VOCs and other organics, depleted uranium, acids, caustics, and metals from these IHSSs.

OU 14 - Radioactive Sites Assessment. OU 14 consists of storage areas for radioactive soils removed from near the radiological operations buildings.

OU 15 - Inside Building Closures Remediation. OU 15 includes structures within buildings where hazardous materials were stored or processed.

OU 16 - Low Priority Sites Assessments. OU 16 covers miscellaneous leak and waste treatment sites that are considered the least likely to cause health or environmental problems. The soils at these sites may have been contaminated by organics, solvents, and nickel carbonyl.

SITEWIDE ACTIVITIES

Sitewide activities include several tasks that encompass a wide variety of plans, procedures, reports, studies, and other activities required by the IAG and that apply to RFP environmental restoration activities in general.

Community Relations Plan

The Final RFP Community Relations Plan (CRP) was submitted to CDH and EPA in January. Public meetings were held in February and March, and written comments were accepted through March 30, 1991. Compilation of the CRP Responsiveness Summary continued through May 1991. As part of the CRP, contractor representatives conducted a buffer zone tour in October 1991 for the TRG, which is composed of representatives from local municipalities and local environmental groups.

Plan for Prevention of Contaminant Dispersion

An Interim and a Final Plan for Prevention of Contaminant Dispersion (PPCD) were submitted to EPA and CDH in February and July, respectively. This plan provides for the management of wastes at individual sites in such a manner as to prevent wind blowing of hazardous materials.

Public comments were received on the PPCD, and the Responsiveness Summary (RS) was prepared. The RS and Final PPCD were submitted to CDH and EPA in November. Comments by these agencies on the RS are being addressed.

Quality Assurance Program Plan

The Sitewide Quality Assurance Program Plan (QAPP) and Sitewide Standard Operating Procedures (SOPs) were submitted to EPA and CDH in March. The QAPP describes sitewide Quality Assurance (QA) requirements, which will be implemented by the DOE, EG&G Rocky Flats, Inc., and all subcontractors conducting remedial investigations and feasibility studies at the RFP. The SOPs detail field techniques to be used during the investigation of the sites and provide guidance for the performance of all fieldwork to ensure that work required by the IAG is performed according to EPA- and CDH-approved methods. After EPA and CDH approval of the QAPP and SOPs, a readiness review is conducted before any field activities begin to verify that all elements are in place.

Discharge Limits for Radionuclides Work Plan

The Draft Radionuclides Discharge Limits Work Plan (RDLWP) was delivered to EPA and CDH in April. The primary focus of this work plan is the monitoring and control of radionuclide concentrations in discharge water. The work plan describes analytical protocols and methods for the determination of radionuclide levels, presents statistical assessments of accumulated analytical results, and recommends additional radionuclide studies to better characterize the water quality of RFP discharges. The work plan describes current procedures for planning, approving, and conducting offsite discharges of water from the RFP terminal ponds A-5, B-4, and C-2. The RDLWP includes procedures for implementing the discharge plan, methods for streamlining operations, current treatment approaches and limitations, and plans for future treatability studies.

EG&G resolved comments from EPA, CDH, and other agencies regarding the draft work plan, and the final plan was submitted in August. A public meeting on the RDLWP was held in October and the public comment period ended in November. The RS to the public comments was submitted to EPA and CDH in January 1992.

Treatability Study Work Plan

The final sitewide Treatability Study Work Plan (TSWP) was delivered to the regulatory agencies in

June. The plan identifies technologies potentially available for use in corrective/remedial actions for each type of waste/waste matrix in sites at the RFP and selects candidate technologies for evaluation in a sitewide treatability studies program. Information is included on performance, applicability, removal efficiencies operation and maintenance requirements, and implementability for the candidate technologies. The plan proposes an SOP for a treatability study for each candidate technology that has not been adequately evaluated on the basis of existing data.

Plutonium in Soils TSWPs were submitted to EPA and CDH in November. The two work plans included in this document address Magnetic Separation and the TruClean Process, which are two technologies selected for the treatability studies in the final Treatability Study Plan.

Site-Specific Chemical Analyte Roster

RFP negotiated Site-Specific Analytical Rosters (S-SCARs) for organic chemicals on OUs 1 and 2. Historically, hazardous waste site analytical programs included extensive use of full Contract Laboratory Program (CLP) analysis, which included analysis of volatile organics, base-neutral and acid extractable organics, and pesticide/PCB organics. S-SCARs are developed using existing data, coupled with environmental fate and transport and risk and regulatory analysis considerations to eliminate suites that are either not present or do not contribute to the overall site hazard. The S-SCAR process entails a media-by-media assessment of individual sampling locations in conjunction with an evaluation of project analytical data requirements. The result is an S-SCAR that is tailored to project data requirements with potential economic savings.

Polychlorinated Biphenyl (PCB) Contamination

In January RFP discovered a potential oil leak in the vicinity of transformer 707-1 on the roof of Building 707. After discovery of the oil leak, limited samples were collected from the transformer, roof, and nearby soils to verify the presence or absence of PCB contamination. The sample results indicated that PCBs were present at all three locations. In March, a more extensive characterization effort was initiated in relation to the building roof and soils adjacent to the drain from the roof.

Once PCBs were determined to be present as a result of a historical release from the vicinity of transformer 707-1, a corrective action plan was developed for Building 707, and additional investigations were initiated relative to PCB sites. A preliminary search of RFP files, documents, and discussions with plant personnel from various departments indicated the possibility of an additional 33 sites.

PCB soil sampling resumed in July. The PCB Preliminary Site Description Plan was completed in October and delivered to the regulatory agencies. PCB contamination identified in future investigations will be incorporated into the remedial efforts of the appropriate OU.

Administrative Record File

The complete Administrative Record File Index for all OUs and Sitewide Activities was provided to EPA and CDH for review and comment in November. Microfiche reader/printers were delivered to the Rocky Flats Reading Room, Rocky Flats Environmental Monitoring Council, and CDH to allow the public an opportunity to review the Administrative Record File.

Protected Area Interim Measure/Interim Remedial Action Plan

A preliminary project plan was initiated in late 1991 to guide assembly of an IM/IRAP for the Protected Area (PA). The PA is the area that contains the major plutonium processing facilities and is subject to a high level of security. All or portions of ten OUs for which RIs are planned are located within the PA. RFP is examining the advantages of deferring the RI process until such time as the PA is no longer impacted by security concerns. This action would provide for better coordination of investigative and remedial effort that would result from the consolidation of geographically similar OUs.

The IM/IRAP will provide a plan under which contaminant sources, potential migration pathways, and potential sensitive receptors for known PA contamination are identified, and alternatives are proposed to stabilize or mitigate any immediate human health or environmental risks. The plan would assess and interpret current data with respect to potential exposure pathways and potential sensitive receptors. The plan would also define ARARs, identify and screen alternatives, and provide documentation for NEPA compliance. A draft IM/IRAP will be completed in 1992.

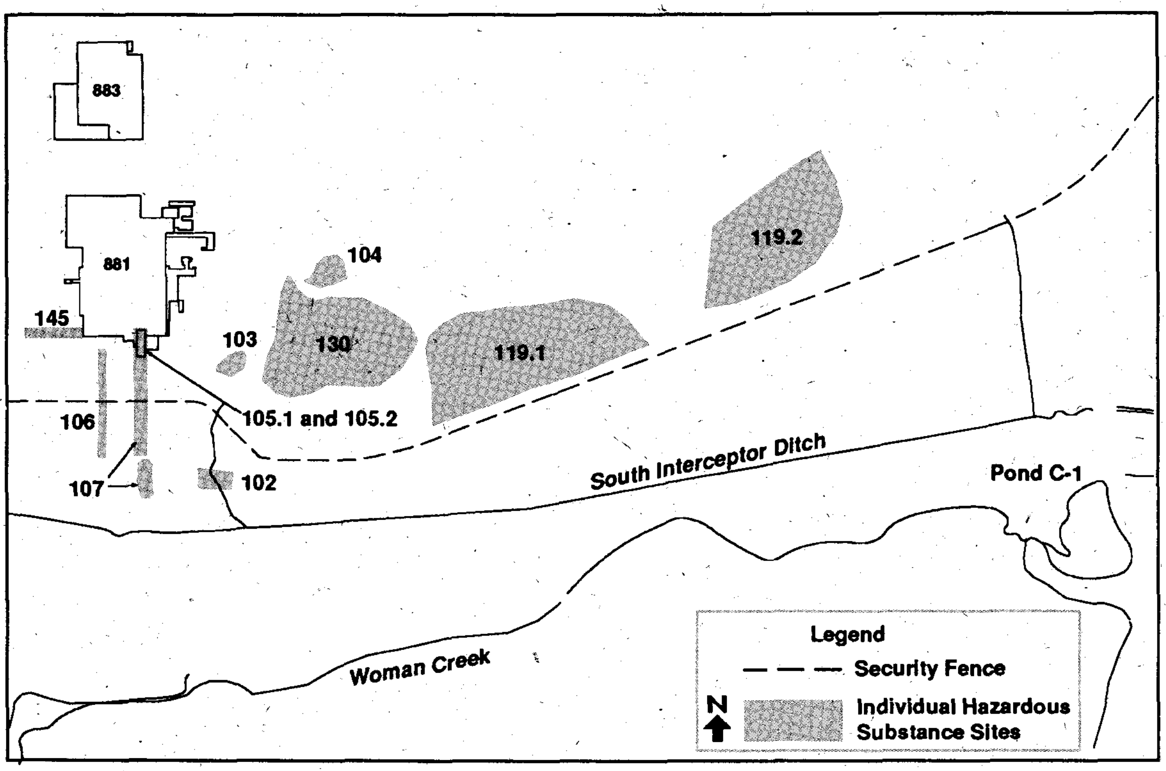


Figure 4-1. Operable Unit 1 - 881 Hillside

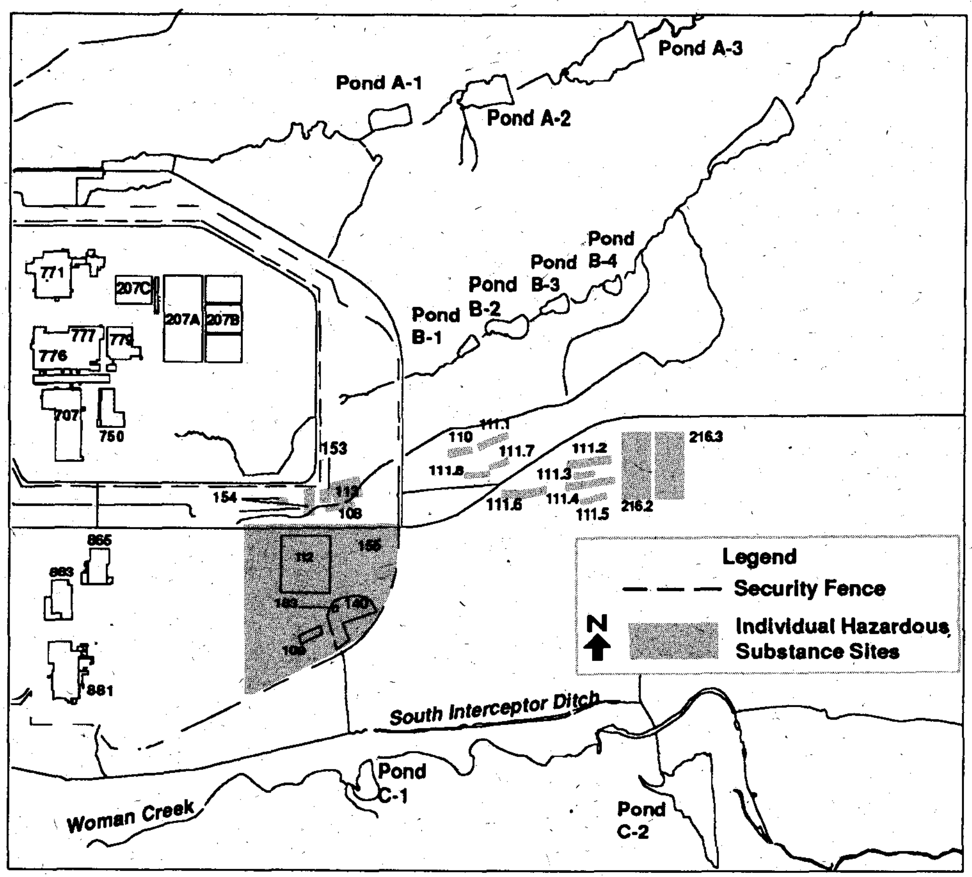


Figure 4-2. Operable Unit 2 - 903 Pad, Mound, East Trenches

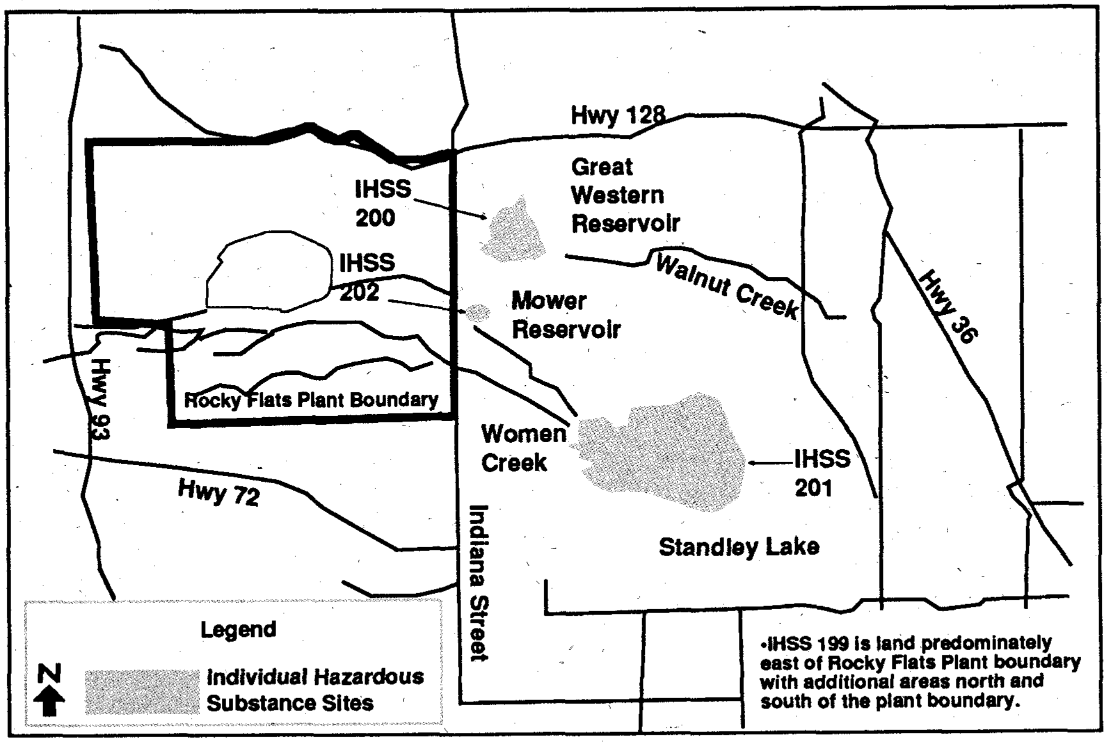


Figure 4-3. Operable Unit 3 - Offsite Releases

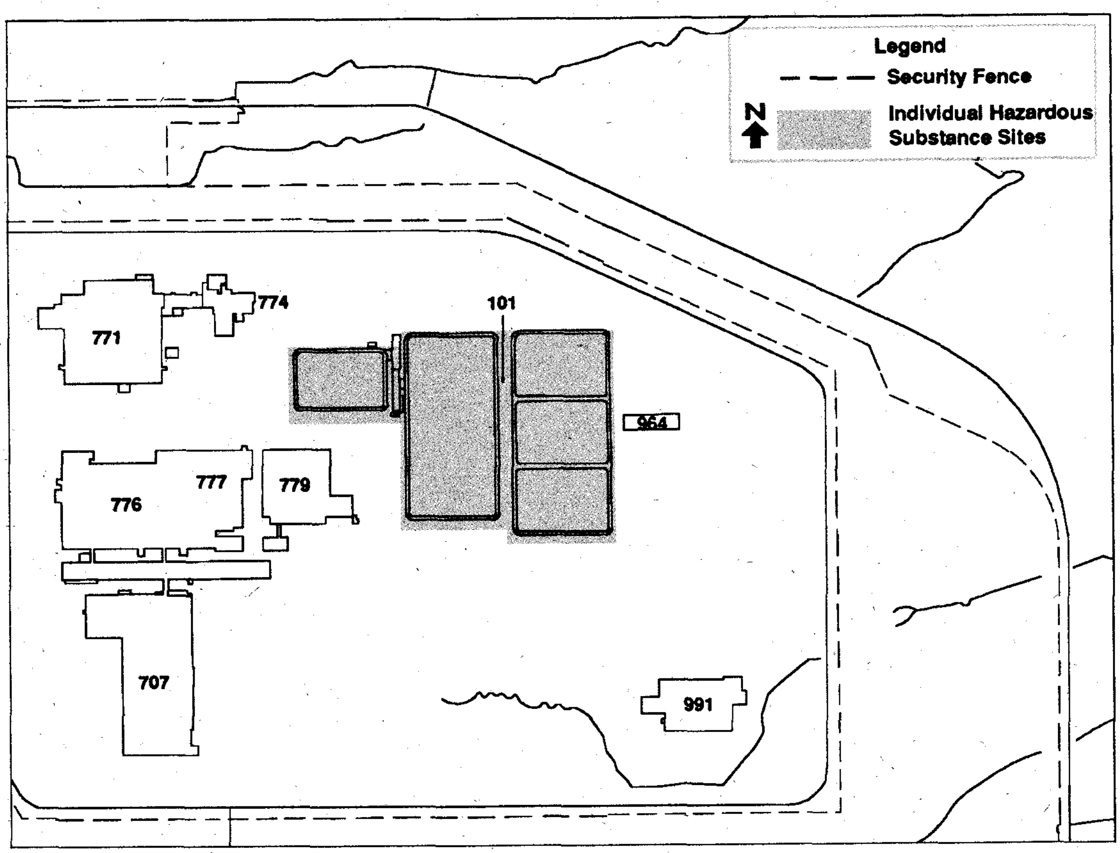


Figure 4-4. Operable Unit 4 - Solar Evaporation Ponds

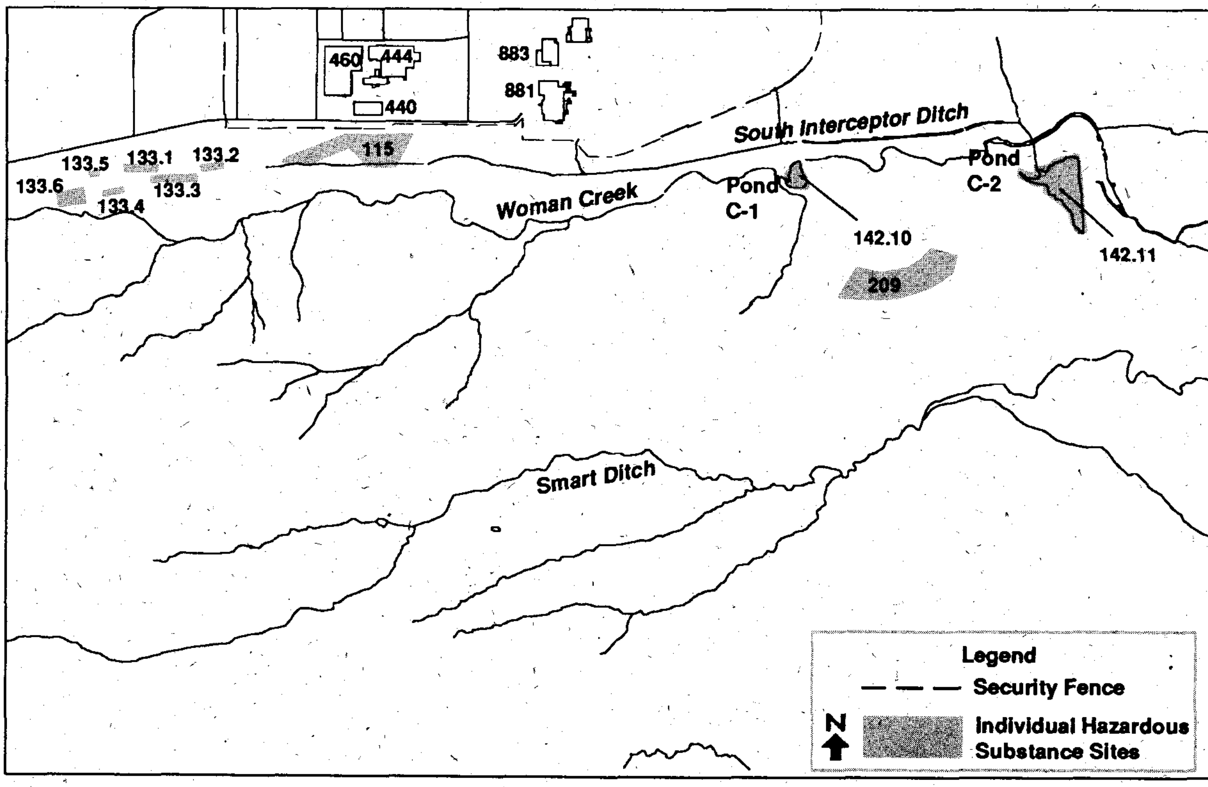


Figure 4-5. Operable Unit 5 - Woman Creek

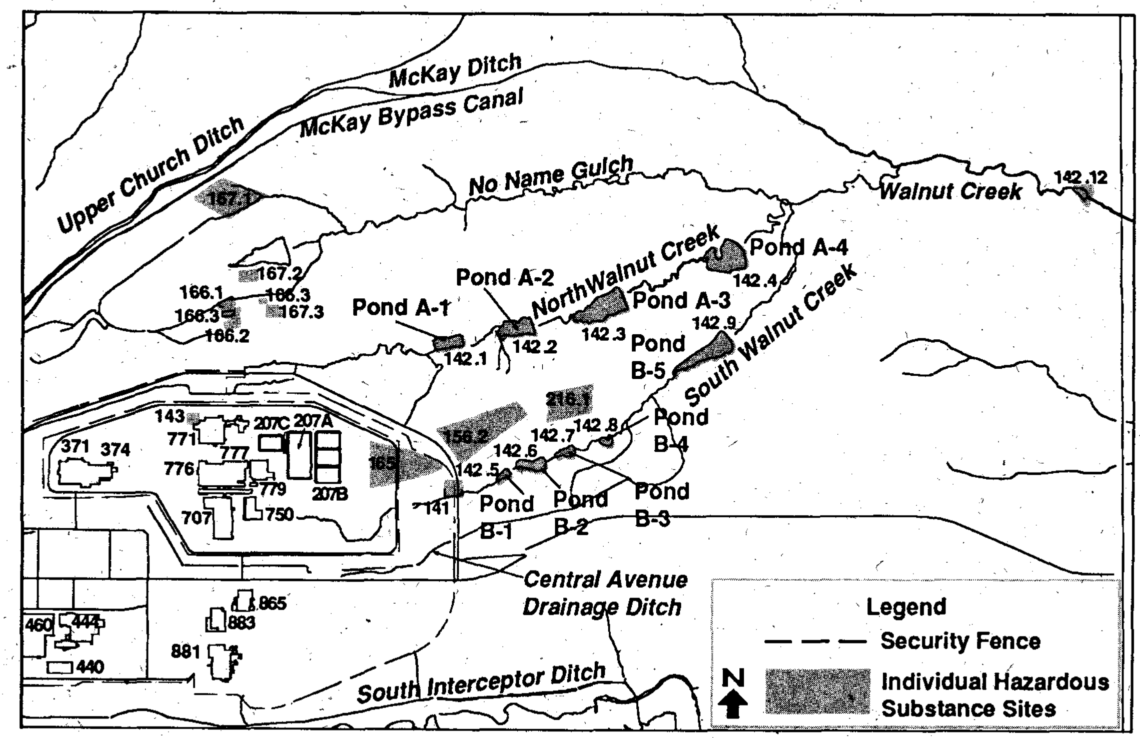


Figure 4-6. Operable Unit 6 - Walnut Creek

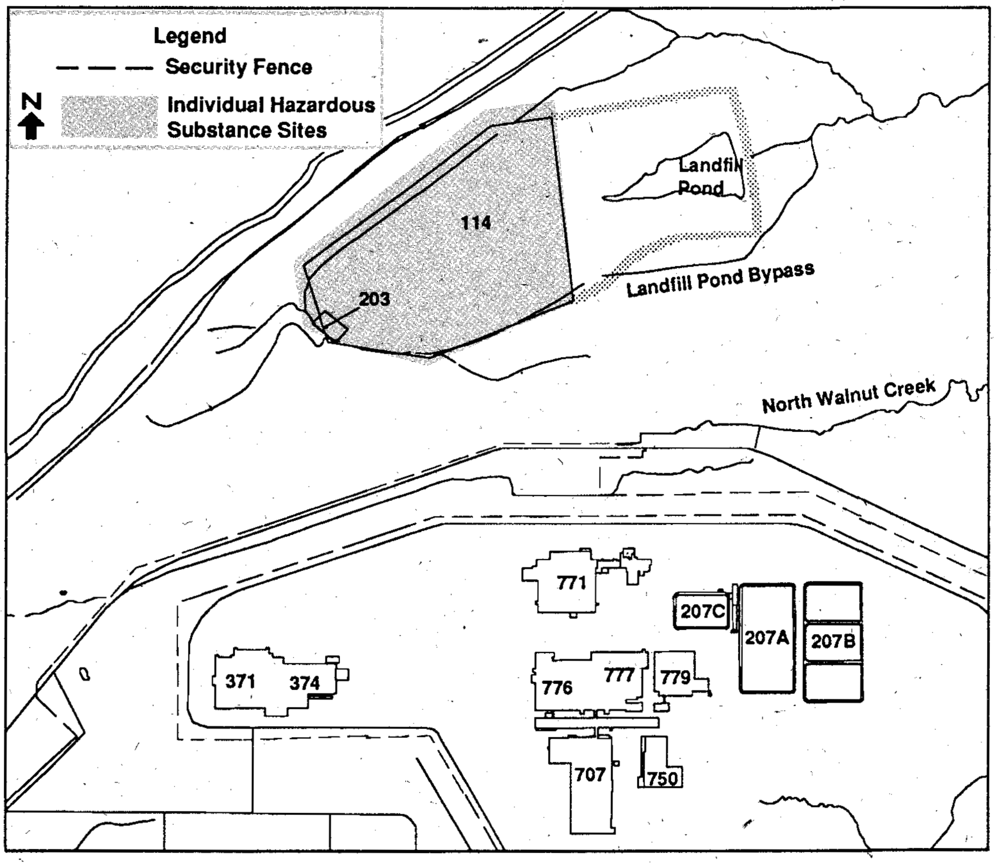


Figure 4-7. Operable Unit 7 - Present Landfill

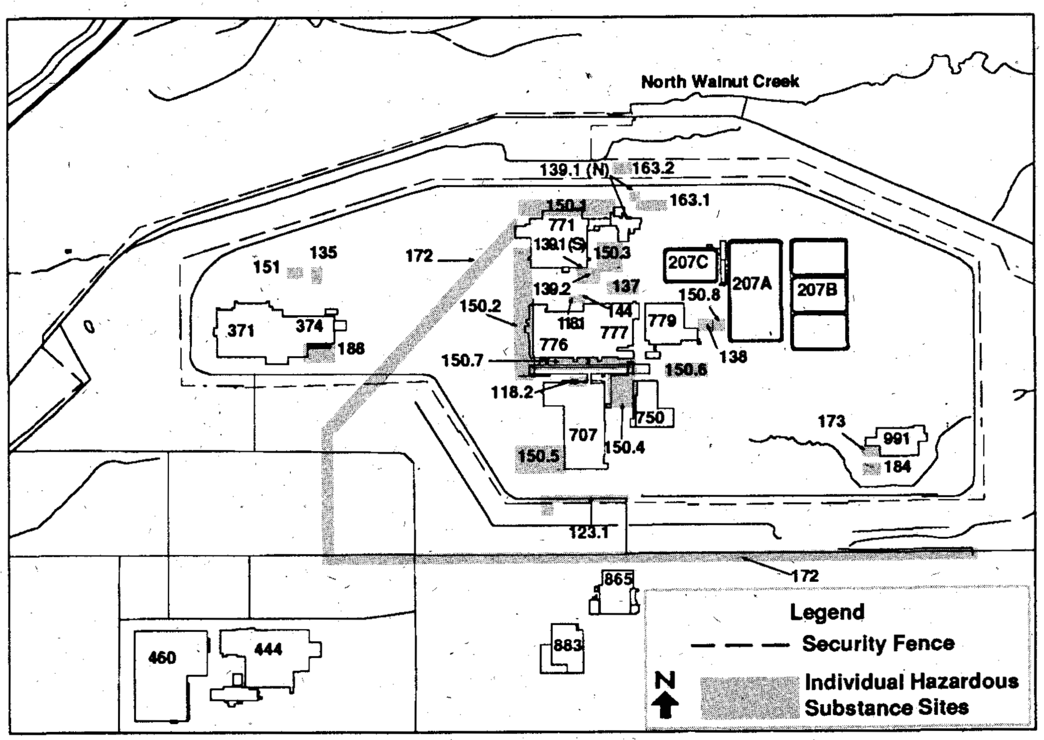


Figure 4-8. Operable Unit 8 - 700 Area

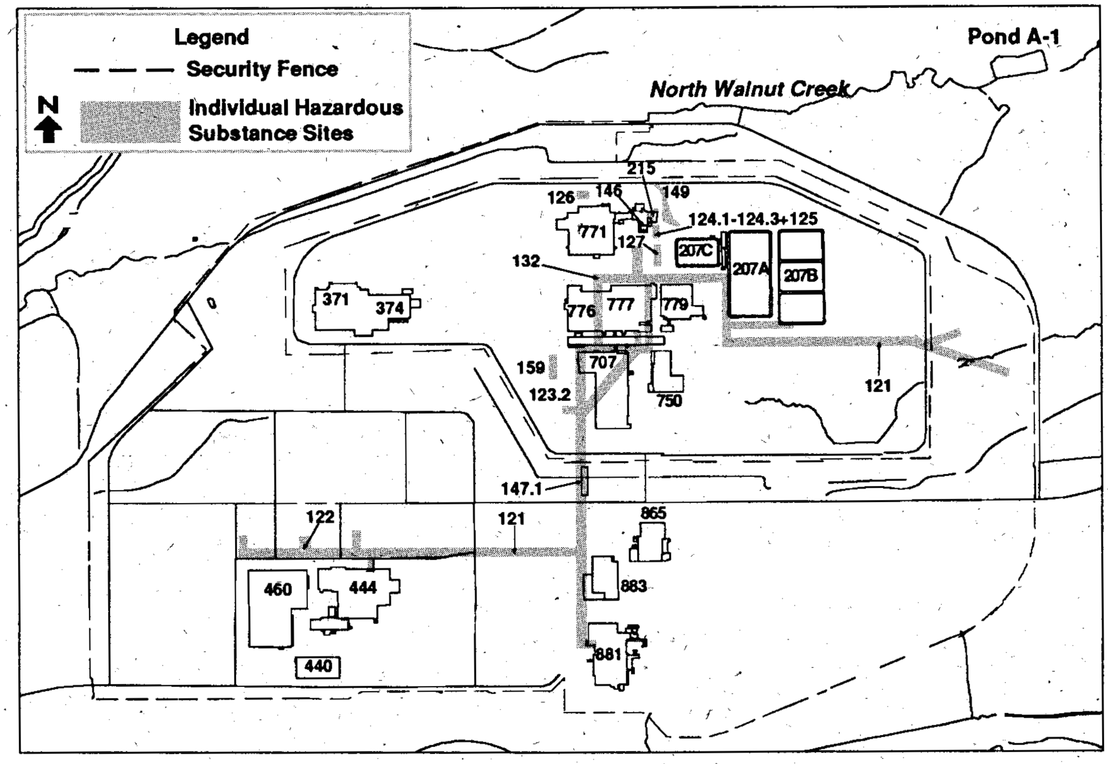


Figure 4-9. Operable Unit 9 - Original Process Waste Lines

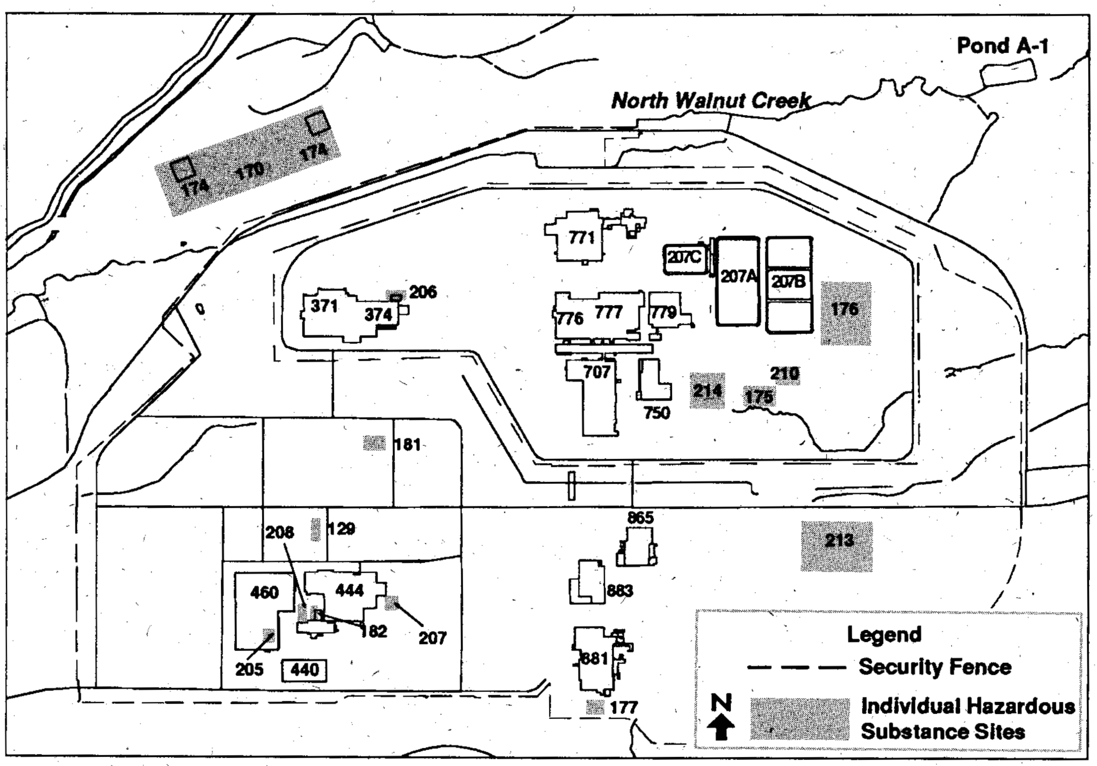


Figure 4-10. Operable Unit 10 - Other Outside Closures

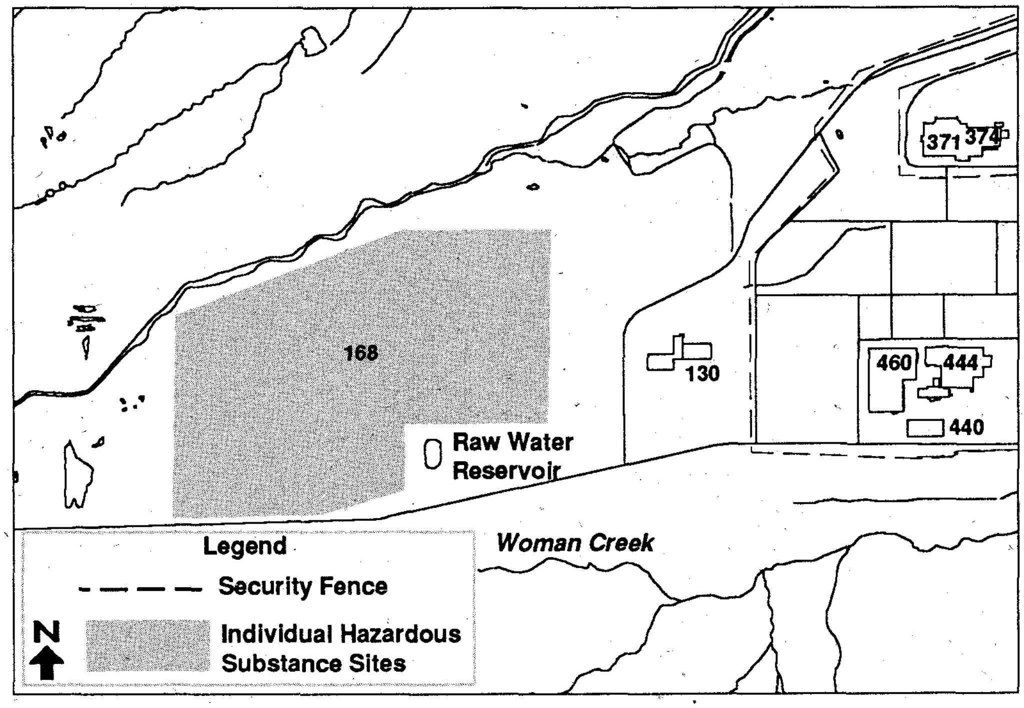


Figure 4-11. Operable Unit 11 - West Spray Field

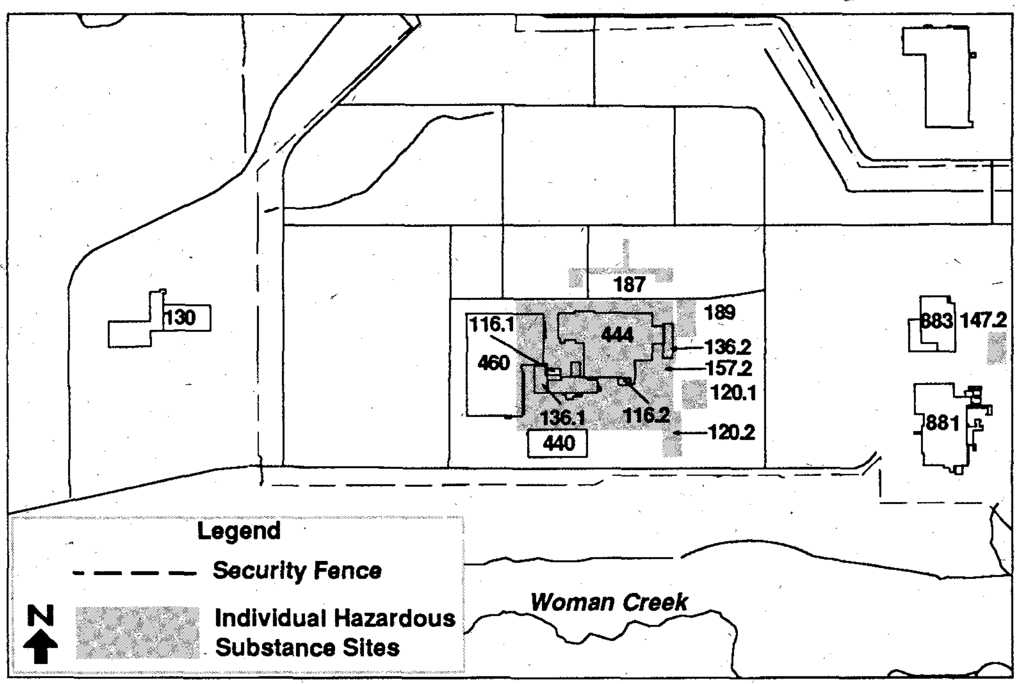


Figure 4-12. Operable Unit 12 - 400/800 Area

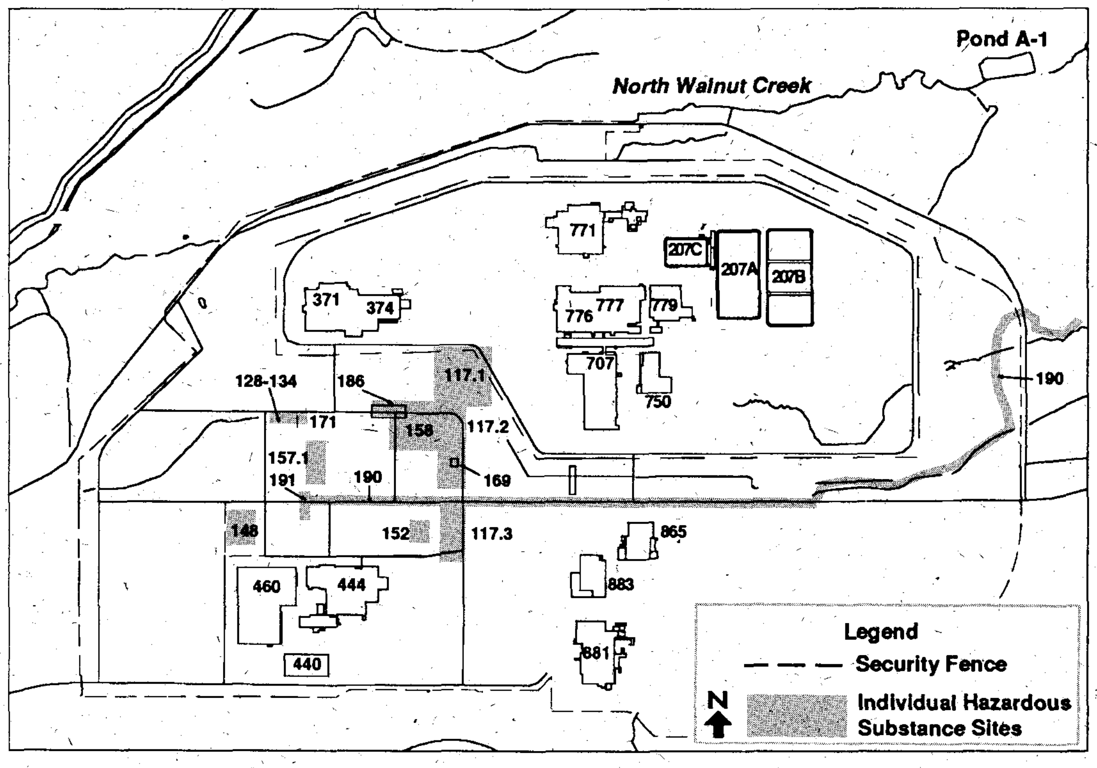


Figure 4-13. Operable Unit 13 - 100 Area

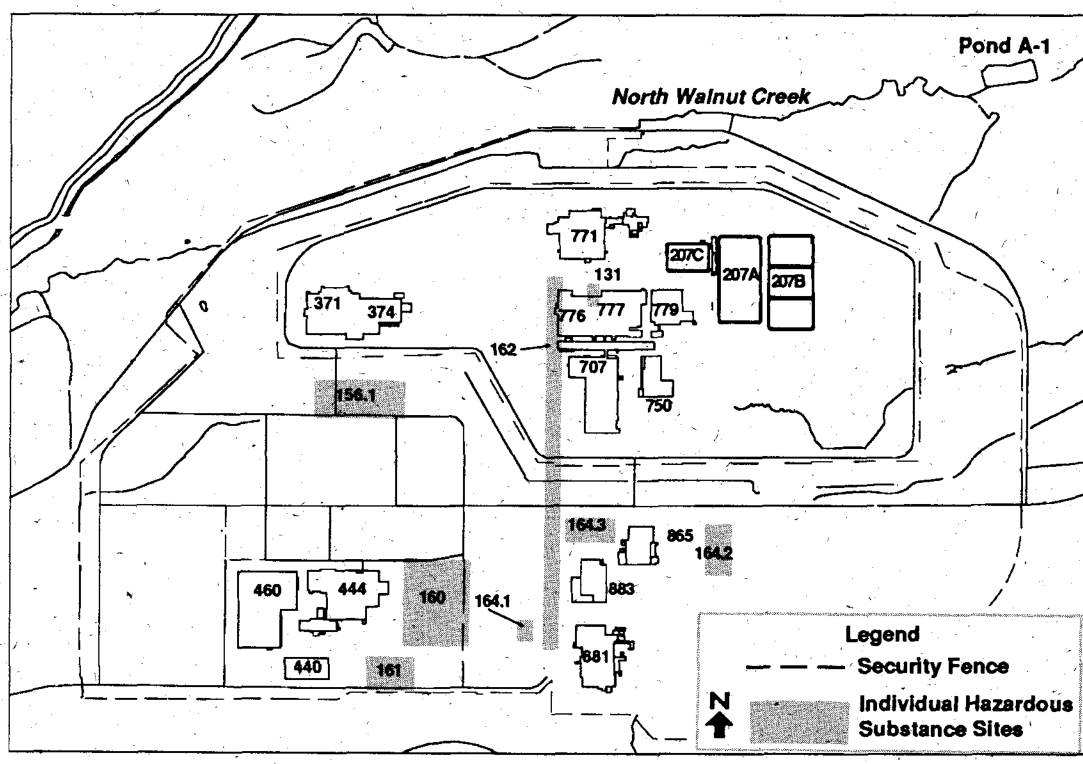


Figure 4-14. Operable Unit 14 - Radioactive Sites

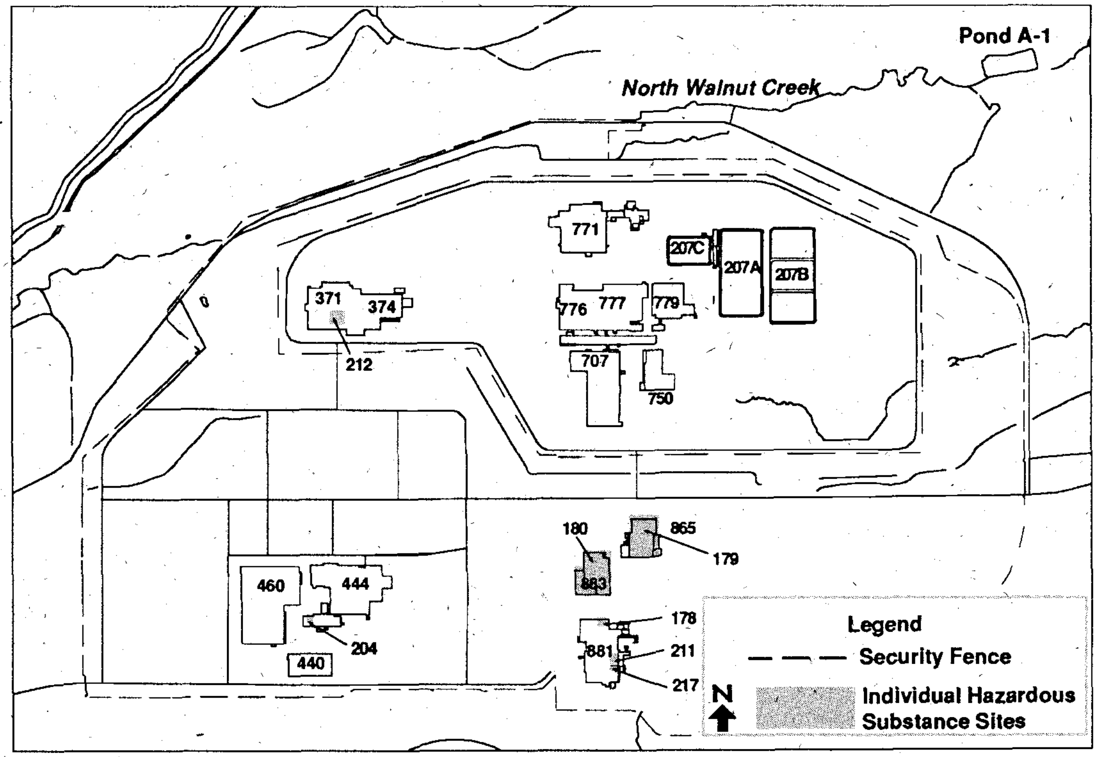


Figure 4-15. Operable Unit 15 - Inside Building Closures

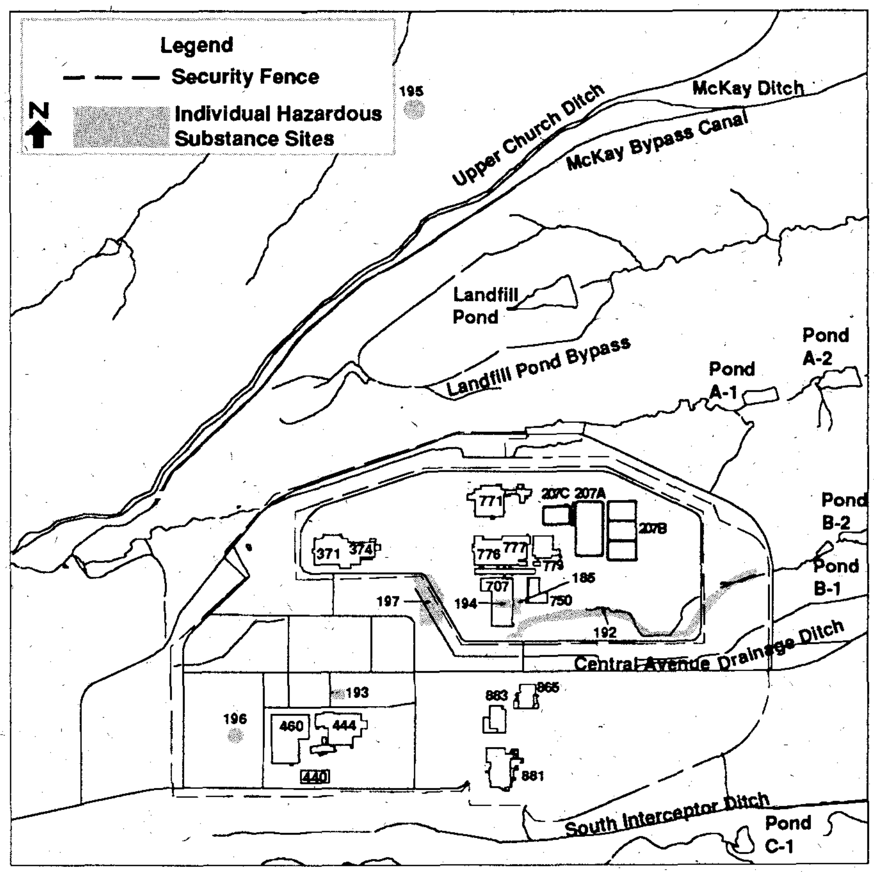
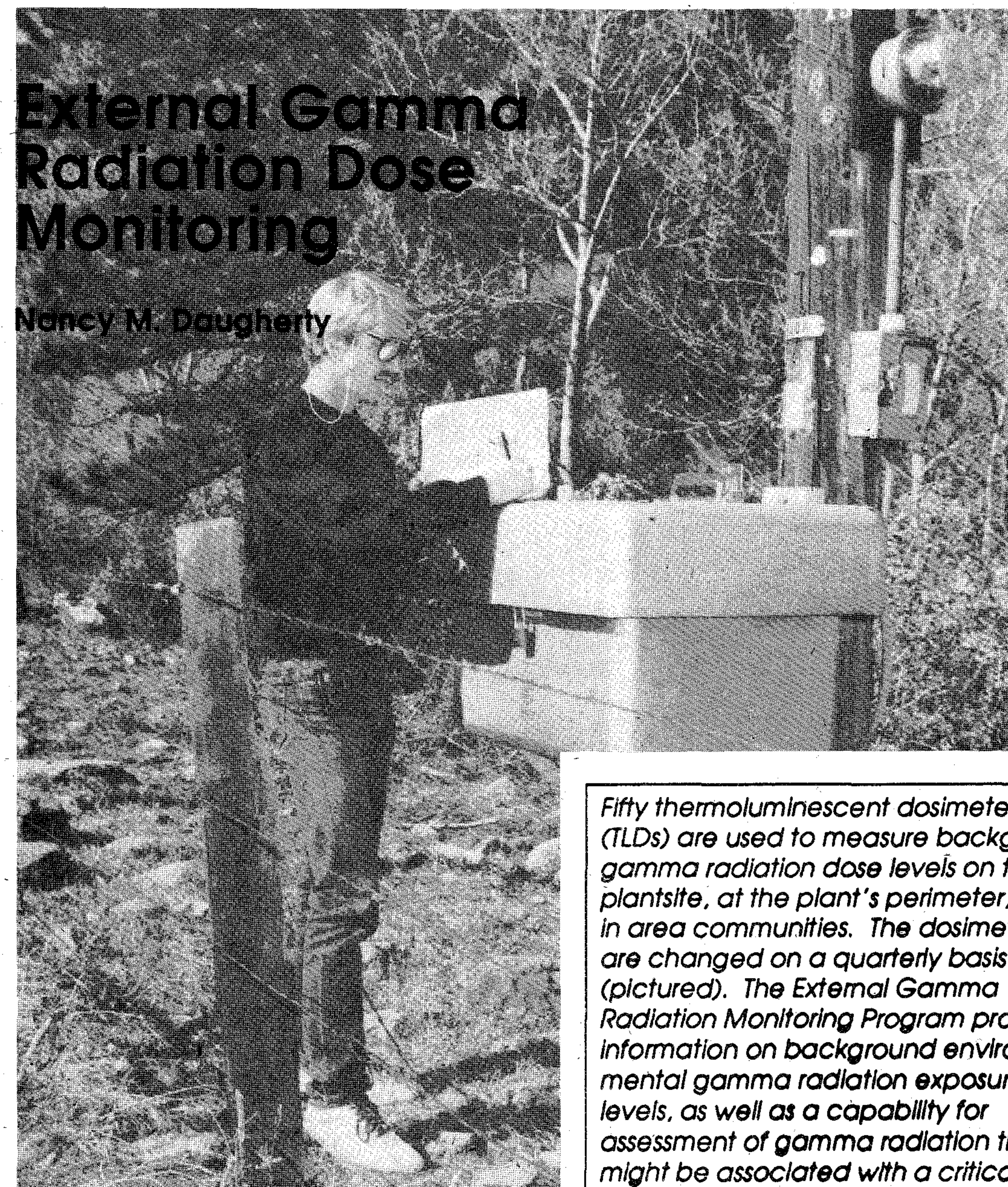


Figure 4-16. Operable Unit 16 - Low Priority Sites

5. External Gamma Radiation Dose Monitoring

Nancy M. Daugherty



Fifty thermoluminescent dosimeters (TLDs) are used to measure background gamma radiation dose levels on the plantsite, at the plant's perimeter, and in area communities. The dosimeters are changed on a quarterly basis (pictured). The External Gamma Radiation Monitoring Program provides information on background environmental gamma radiation exposure levels, as well as a capability for assessment of gamma radiation that might be associated with a criticality accident emergency situation.
This section provides results of the TLD measurements during 1991.

OVERVIEW

TLDs contain a luminescent material that absorbs energy from exposures to ionizing radiation. When the TLD is later heated under controlled conditions, the energy is released as visible light. This light is measured and can be used to indicate the external gamma radiation dose that a person could receive under the same exposure conditions. The primary radioactive materials to which the public might be exposed as a result of RFP activities emit relatively little penetrating gamma radiation. The most important potential source of radiation dose to the public from RFP activities is the alpha radiation from inhalation or ingestion of plutonium, americium, or uranium. Gamma radiation measured with the RFP TLDs is primarily from naturally occurring cosmic and primordial sources.

RFP has 50 TLD monitoring locations with replicate TLDs at each location. Five of these locations are within Building 123, the building housing the laboratory in which the TLDs are prepared and read out. In past annual site reports, data from only one location in Building 123 were used. This year, all five of the locations are included in the reported onsite data.

During 1991, all TLDs were replaced after an exposure of approximately 4 months. The TLDs are placed at 22 locations within the property enclosed by the security fence (including five locations in Building 123) (Figure 5-1). Measurements are also made at 16 perimeter locations 2 to 4 miles from the center of RFP (Figure 5-2) and in 12 communities located within 30 miles of RFP (Figure 5-3). The TLDs are placed at a height of about 3 feet above ground level.

During 1983, conversion from a Harshaw TLD system to a Panasonic system was initiated. For one complete calendar year, two TLDs of each type were used at each monitoring location. Beginning in 1984, only Panasonic TLDs have been used. It was determined that a statistically significant difference in response exists between the Harshaw environmental monitoring system and the Panasonic environmental monitoring system. To compare 1990 values with the Harshaw data reported prior to 1984, it is necessary to multiply the Panasonic results given in Table 5-1 by 1.046.

During 1991, new processing hardware and software were acquired for the Panasonic readers. A new multi-tasking, multi-user computer system that allows simultaneous data accumulation from several readers, as well as concurrent data processing, was put into service. This advanced system uses a new whole body dosimeter badge algorithm and new TLDs. The system, called the VAX/ISA system, passed rigorous DOE laboratory accreditation testing during the year and was recommended for accreditation.

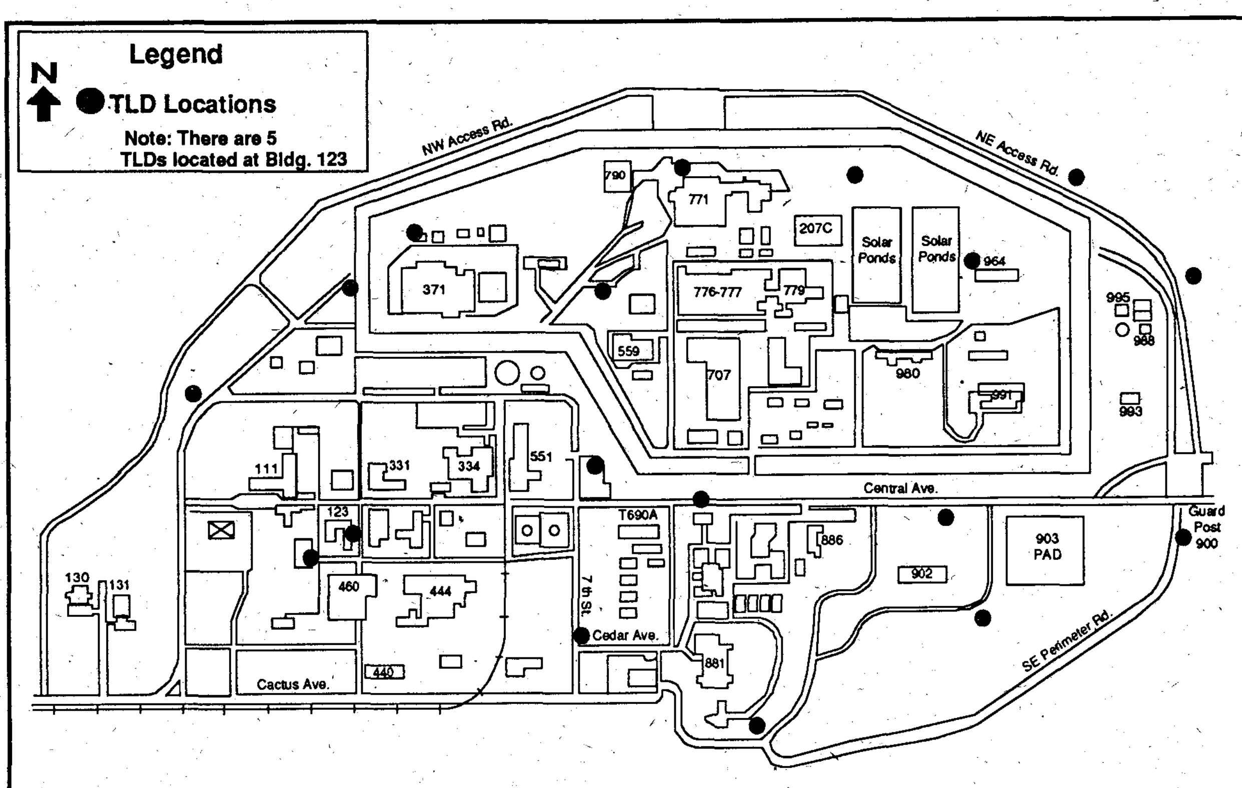


Figure 5-1. 22 TLD Locations within the Main Facilities Area

During the first 4 months of the year, sets of TLDs from both the old and the new system were deployed in all of the environmental monitoring locations. A statistically significant difference exists between the results from the two systems; the source of this difference is currently under review. It is likely a result of a combination of factors such as different calibration sources,

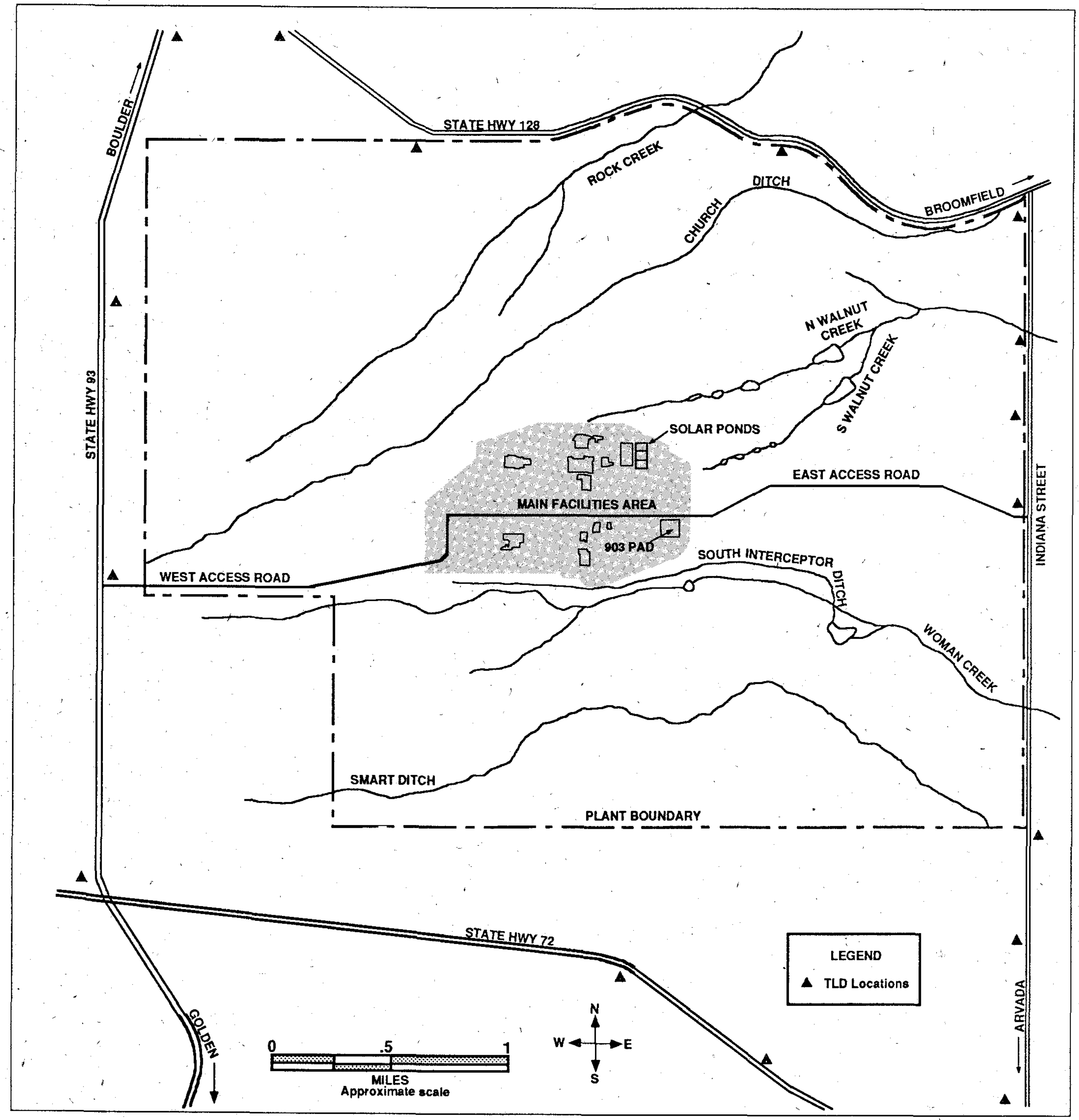


Figure 5-2. 16 TLD Locations Within a 2- to 4-Mile Radius from RFP

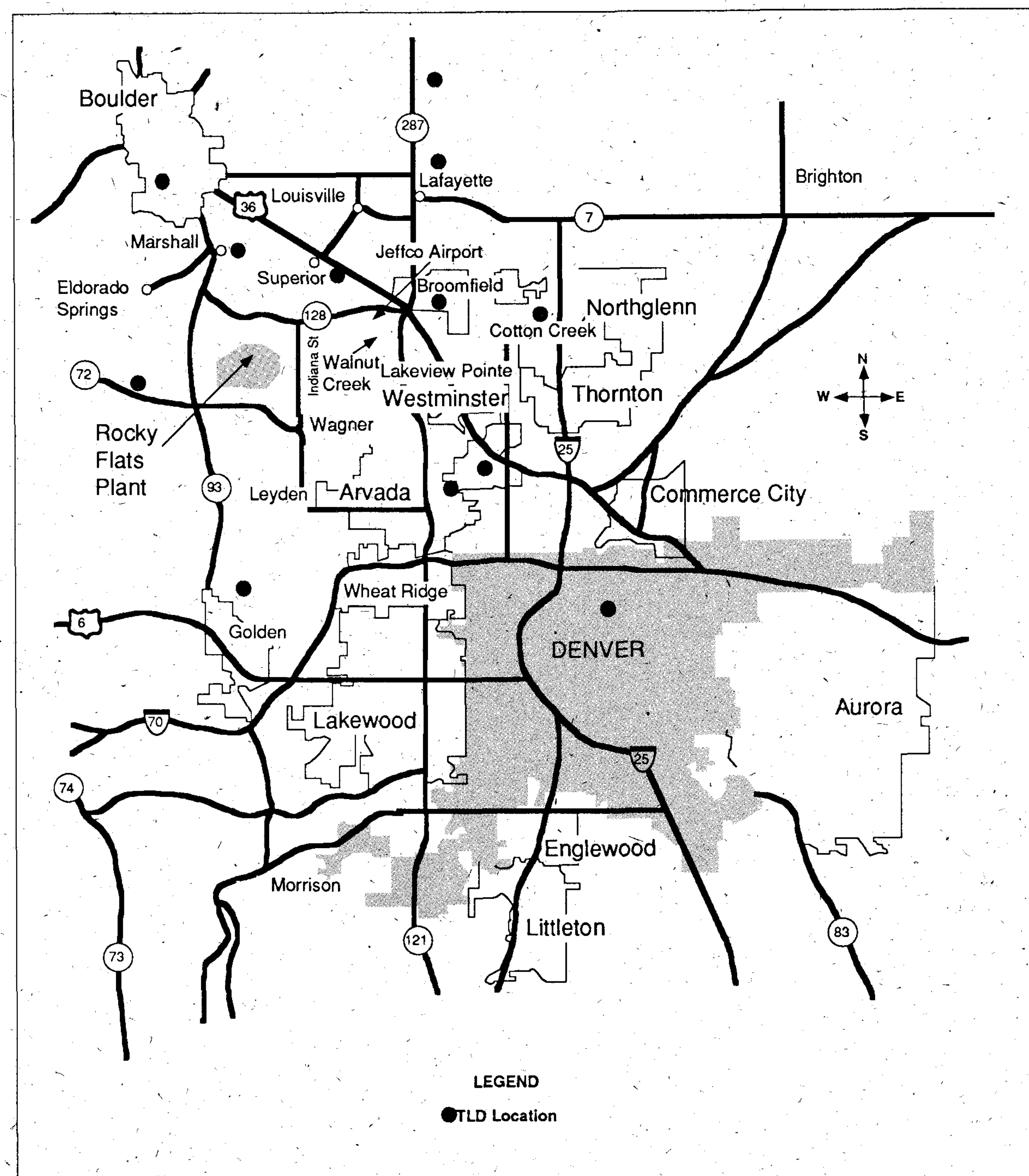


Figure 5-3. 12 TLD Locations in Communities Located Within a 30-Mile Radius of RFP

different calibration conditions, better element correction factors used in the VAX/ISA system, and different reader conditions. To compare the results obtained from the VAX/ISA system to the values obtained by the Panasonic system used before 1991, it is necessary to multiply the results for CY91 by 1.3.

The Panasonic environmental TLDs normally consist of two model 802 dosimeters, each having four elements. (However, during the first 4 months of 1991, only one model 802 dosimeter from each system was fielded.) Only one of the elements of each dosimeter is used. This element consists of calcium sulfate, thulium drifted (CaSO4:Tm), deposited on a polymid surface. The phosphor is covered with clear Teflon and backed with an opaque ABS plastic. The TLDs are packaged in a small plastic bag, a paper envelope, and another plastic bag to protect them from the weather. Total filtration over the phosphor is 178.5 milligrams per square centimeter (mg/cm^2).

The TLDs have been calibrated individually (three times each) against an onsite cesium-137 gamma calibration source. Calibration linearity studies have confirmed that TLD response is linear for exposure levels ranging from 10 mrem to 1,000 mrem. The mean calibration factor for each dosimeter is applied to measurements taken with that dosimeter. In addition, quality control dosimeters are read with each group of TLDs to ensure that the variability in the readers is within limits.

The annual dose equivalent for each location category was calculated by determining the average millirem per day (mrem/day) for each of the three categories, using data from the three trimesters of 1991. These values were then multiplied by 365.25 to obtain yearly totals.

In previous annual reports, the annual measured dose was reported with a 95 percent confidence interval on the mean, using the standard error of the mean, calculated from the variance of the individual measured values. Beginning in 1985, the 95 percent confidence interval on an individual observation within each location category, calculated as 1.96 standard deviations, was added to the report. This latter interval may be used for assessing the variability of the individual location measurements within a location category.

RESULTS

The 1991 environmental measurements using TLDs are summarized in Table 5-1. The average annual dose equivalents, as measured onsite, in the perimeter environs and in local communities, were 122, 109, and 120 mrem (1.22, 1.09, and 1.20 millisieverts [mSv]), respectively. These values are similar to those reported by the National Council on Radiation Protection and Measurements (NCRP) for background gamma radiation in the Denver area. The NCRP reported an annual range of 125 - 190 mrem (1.25 - 1.90 mSv) (NA87b).

Table 5-1

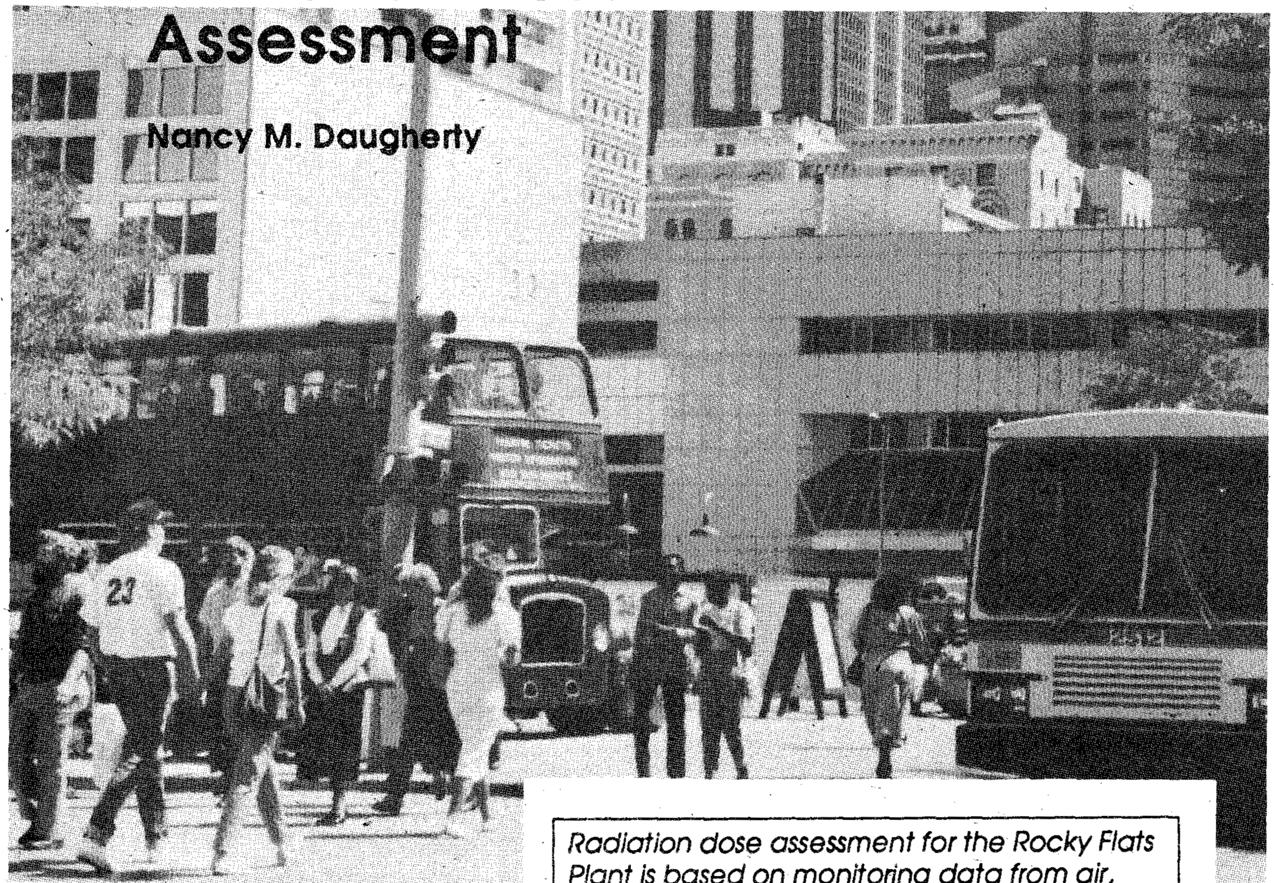
Environmental Thermoluminescent Dosimeter Measurements

Location Category	Number of Locations	Number of Measurements	Mean Annual Measured Dose (mrem)	95% Confidence Interval on the Mean (mrem)[a]	95% Confidence Interval on an Individual Measurement (mrem)[b]
Onsite	22	108	122	±4	±42
Perimeter	16	79	109	±2	±20
Community	12	50	120	±3	±23

a. Calculated as 1.96 standard deviations of the mean.
b. Calculated as 1.96 standard deviations of the individual measurements.

6. Radiation Dose Assessment

Nancy M. Daugherty



Radiation dose assessment for the Rocky Flats Plant is based on monitoring data from air, water, and soil sampling programs. The 1991 assessment of dose to the public from RFP activities indicates that the radiation dose to the maximally exposed individual in the public is estimated to be 0.32 millirem effective dose equivalent (EDE). For comparison, the average person in the United States receives approximately 300 millirem EDE from natural background radiation sources.

ROCKY FLATS PLANT RADIOACTIVE MATERIALS

Radioactive materials included in estimating radiation dose to the public from RFP activities are plutonium, uranium, americium, and tritium. Plutonium and americium in RFP environs are the combined result of residual fallout deposition from global atmospheric nuclear weapons testing and releases from the plant. Uranium, a naturally occurring element, is indigenous to many parts of Colorado and is used in RFP operations in various isotopic ratios. Tritium is both naturally occurring and produced artificially and is sometimes handled in RFP operations.

In the dose assessment performed for CY91, internal exposure to alpha radiation emissions from water ingestion of plutonium, uranium, and americium is the primary contributor to the projected radiation dose.

The 1991 radiation dose assessment includes modifications to assumptions used in previous annual site environmental reports for potential pathways of exposure to the public. The 1991 assumptions are intended to reflect potential exposure conditions more accurately. In previous annual RFP site environmental reports, the approach taken for dose assessment was extremely conservative, based on assumptions for a hypothetical individual that would tend to maximize the resulting dose estimate, but which were known to be unrepresentative of actual living habits in the RFP area. DOE Order 5400.5 encourages the use of more realistic, but still conservative, approaches to dose assessment. The approach documented in this 1991 report is believed to be more realistic than in previous reports in reflecting actual residential areas and pathways of exposure in the RFP vicinity. However, the 1991 report approach continues to employ conservative assumptions of intake rates, exposure duration, and solubility of radioactive contaminants. Adding to the conservatism is the lack of subtraction of background (non-RFP related) contributions of radioactive contaminants in air and soil concentrations and in water concentrations for radionuclides other than uranium.

The assumptions made for the water ingestion pathway also continue to be conservative. The source of potential water ingestion, Pond C-2 discharges, was chosen to provide an upper bound to radioactivity concentrations for water ingestion, although it is known that no individual is actually using Pond C-2 as a drinking water supply at this location. Throughout 1991, RFP surface water was not discharged directly to any public drinking water supply. As data for other monitoring locations become available in the future, more realistic assumptions regarding this pathway may be made. Background subtraction is performed only for uranium concentrations in this water source term. Correction for background uranium concentrations in water is made because of the large relative contribution to this pathway from naturally occurring uranium.

Direct ingestion of soil was added to the 1991 exposure scenario, consistent with recommendations by the EPA for performance of risk assessments (EPA89a).

Previous pathway assessments in the *Environmental Impact Statement, Rocky Flats Plant Site* indicate that swimming and consumption of foodstuffs are relatively insignificant contributors to public radiation dose (DOE80). Swimming and fishing are limited in the area, and most locally consumed food is produced at considerable distances from the plant. A pathway analysis review performed under contract to RFP by the Colorado State University Department of Radiological Health Sciences confirmed the relative insignificance of these pathways (FR92).

The results of the 1991 assessment of dose to the public from RFP activities indicate that the radiation dose to the maximally exposed individual in the public is estimated to be 0.32 millirem (3.2×10^{-3} mSv) effective dose equivalent (EDE). The collective population dose to a distance of 80 kilometers (50 miles) is estimated as 1 person-rem (1×10^{-2} person-sievert [Sv]). These calculated radiation doses are believed to be conservative estimates that would be an upper bound for any radiation doses actually received by the public. The greatest contributor (over 79 percent) to the estimated dose to the maximally exposed individual is ingestion of uranium (57 percent), plutonium (14 percent), and americium (8 percent) in water. More specific information regarding the 1991 radiation dose assessment follows.

Radiation Protection Standards for the Public

Standards for protection of the public from radiation are based on radiation dose, which is a means of quantifying the biological effect or risk of ionizing radiation. In the United States, the unit commonly used to express radiation dose is the rem or the millirem (1 rem = 1,000 mrem). The comparable International Standard (SI) unit of radiation dose is the sievert (1 sievert [Sv] = 100 rem). Radiation protection standards for the public are annual standards, based on the projected radiation dose from a year's exposure to or intake of radioactive materials.

Radiation protection standards applicable to DOE facilities are based on recommendations of national and international radiation protection advisory groups and on radiation protection standards set by other federal agencies. On February 8, 1990, DOE adopted revised radiation protection standards for DOE environmental activities (DOE90a). These standards incorporate guidance from the NCRP, the International Commission on Radiological Protection (ICRP), and the EPA Clean Air Act NESHAP, as implemented in 40CFR61, Subpart H (EPA85). Effective December 15, 1989, EPA revised NESHAP standards for airborne emissions of radionuclides from DOE facilities (EPA89a). These new NESHAP standards apply to air emissions from RFP in 1991 and are incorporated into the revised DOE standards.

Table 6-6 and Appendix B, Table B-1, summarize the revised DOE radiation protection standards for the public as established in 1990. The revised NESHAP standards of December 15, 1989, are included.

Radiation Dose

In this 1991 dose assessment, radiation *dose* is calculated by multiplying radioactivity concentrations in air, water, and soil by assumed intake rates (for internal exposures) or exposure times (for external exposure to penetrating radiation). These products then are multiplied by the appropriate radiation dose conversion factors as follows:

Radiation Dose =
(Radioactivity Concentration) X
(Intake Rate or Exposure Time) X
(Radiation Dose Conversion Factor)

In calculating radiation *dose equivalent*, differences in the biological effect of different types of ionizing radiation (e.g., alpha, beta, gamma rays, or X-rays) are accounted for in the dose conversion factor. Radiation energy absorbed in the tissue of interest is calculated and then multiplied by a modification factor based on the type and energy of the ionizing radiation involved. One millirem of dose equivalent from alpha radiation would have the same biological effectiveness on a particular organ as one millirem of dose equivalent from gamma radiation. Dose equivalent can be calculated for the whole body when there is uniform irradiation of all tissues, or for individual organs as might be done when selected tissues are irradiated nonuniformly.

In 1985, DOE adopted radiation protection standards for the public based on the concept of EDE. The December 15, 1989, EPA NESHAP standards also incorporate EDE as the basis for radiation protection for the public from airborne emissions of radioactivity. Previously, whole body dose equivalent and individual organ dose equivalent, as described above, were used for this purpose. The following dose assessment for 1991 uses EDE as the basis for radiation protection of the public, but it includes some individual organ dose equivalents for comparison with previous RFP annual reports.

EDE is a means of calculating radiation dose that allows comparisons of the total health risk of cancer mortality and serious genetic effects from exposures of different types of ionizing radiation to different body organs. EDE is calculated by first determining the dose equivalent to those organs receiving significant exposures, multiplying each organ dose equivalent by a health risk weighting factor, and summing those products. The health risk weighting factors used in the calculation of EDE normalize the risk against a whole body radiation dose. Therefore, the health risk (from cancer mortality and genetic damage) that is associated with 1 mrem of EDE is comparable to the risk associated with 1 mrem of whole body dose equivalent. Likewise, 1 mrem of EDE from natural background radiation would have the same health risk as 1 mrem of EDE from artificially produced sources of radiation, regardless of which organ(s) receives the dose.

Radioactivity Concentration

Radioactivity concentrations or source terms used in calculating dose can be determined from actual samples and measurements in the environment taken at the locations of interest. Alternatively, for airborne releases, these concentrations can be calculated by modeling the atmospheric dispersion of air emissions from buildings and contaminated land areas.

In the following dose assessment, actual environmental measurements near locations of interest are used to determine compliance with the DOE radiation standard for all pathways. These measurements are used to calculate annual average concentrations of radioactive materials in air and soil at the RFP boundary and for the water pathway at the Pond C-2 discharge point.

As required in federal regulation 40CFR61, an EPA-approved computer code is used to determine compliance with CAA NESHAP radionuclide emissions standards for the air pathway only. The EPA-approved code, AIRDOS-PC, includes air dispersion modeling of measured air emissions from buildings and contaminated land areas, as well as dose conversion factors for calculating final radiation dose.

Intake Rate or Exposure Time

Intake rates of radioactive materials used to represent air inhalation and water ingestion for 1 year are prescribed by the DOE (DOE88b, DOE90a). The rates for air and water are based on recommendations of the ICRP (IN75). The breathing and water ingestion rates for 1 year are 8,400 cubic meters and 730 liters, respectively. The EPA provides recommendations for soil ingestion rates in *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)* (EPA89b). The EPA guidance for direct ingestion of soil by an adult is 100 milligrams per day. Exposure times for external penetrating radiation are assumed to be 1 year, as prescribed by DOE (DOE 90a).

Radiation Dose Conversion Factors

Radiation dose conversion factors used for determining compliance with DOE standards for all pathways are prescribed by DOE (DOE88a, DOE88b, DOE90a). Dose conversion factors for internal exposures are based on recommendations of the ICRP (IN79). Dose conversion factors for external exposures to penetrating radiation are based on a methodology developed at Oak Ridge National Laboratory (ORNL) (KO81, KO83), with modifications by the original author (DOE88a).

The plutonium handled at RFP is a mixture of plutonium isotopes having different atomic masses and may include americium-241 in the mixture. Relative abundances of plutonium and americium isotopes in plutonium typically used at RFP (Table 6-1) were used to calculate composite dose conversion factors for plutonium and americium in air and for plutonium in water and soil. The relative abundances used in developing the composite dose conversion factors were based on the isotopic activity fractions of plutonium-239 and -240, since these are the isotopes measured in environmental monitoring sample analyses. Fractions of ingested radionuclides absorbed from the gastrointestinal tract and lung clearance classes for inhaled radionuclides were chosen to maximize the associated internal dose conversion factors and the resulting radiation dose. Each internal dose conversion factor is for a 50-year dose commitment from 1 year of chronic exposure. That is, the dose that an individual could receive for 50 years following 1-year's chronic intake of radioactive material is calculated. The dose conversion factors used in this assessment are listed in Table 6-2. These dose conversion factors incorporate the intake rates and exposure times discussed above.

Table 6-1
Isotopic Composition of Plutonium Used at the RFP

Isotope	Relative Weight (Percent)	Specific Activity (Ci/g)	Relative Activity[a] (Ci/g)	Fraction of Pu Alpha Activity[b]	Fraction of Pu-239, -240 Activity[c]
Pu-238	0.01	17.1	0.00171	0.0233	0.0239
Pu-239	93.79	0.0622	0.05834	0.7962	0.8153
Pu-240	5.80	0.228	0.01322	0.1804	0.1847
Pu-241	0.36	103.5[d]	0.37260[d]	5.085[d]	5.207
Pu-242	0.03	0.00393	1.18×10^{-6}	1.61×10^{-5}	1.65×10^{-5}
Am-241				0.20[e]	0.205

a. Obtained by multiplying the relative weight percent by the specific activity.
b. Obtained by dividing the relative activity by the sum of the relative activities for the plutonium alpha emitters.
c. Obtained by dividing the relative activity by the sum of the relative activities of Pu-239 and Pu-240.
d. Beta Activity.
e. The value for Am-241 is taken to be 20 percent of the plutonium alpha activity.

The EPA-approved computer code AIRDOS-PC, used to determine compliance with the CAA NESHAP standard for the air pathway, incorporates EPA's own approved dose conversion factors. Measured plutonium emissions were modeled for the isotopes plutonium-238 and plutonium-239, -240. Specific analyses for plutonium-241 and -242 are not performed on environmental samples, but these isotopes would be relatively insignificant contributors to total dose. Plutonium-241 emits primarily beta radiation with a very small internal dose conversion factor; plutonium-242 emits primarily alpha radiation, but is a small component of the total plutonium activity mix (Table 6-1). The AIRDOS-PC default values for lung clearance class and gastrointestinal uptake fraction were used when running this code.

Table 6-2
Dose Conversion Factors Used in Dose Assessment Calculations for the RFP in 1991

INHALATION $\left[\frac{\text{Rem * Milliliter}}{\text{Microcurie}}\right]$ a,b

Organ	Pu-239, -240
Effective Dose Equivalent	5.71×10^{12}
Liver	2.22×10^{13}
Bone Surfaces	1.04×10^{14}
Lung	1.08×10^{13}

SOIL INGESTION $\left[\frac{\text{Rem * Gram}}{\text{Picocurie}}\right]$ a,g

Organ	Pu-239,-240	Am-241
Effective Dose Equivalent	1.77×10^{-4}	1.64×10^{-4}
Liver	6.58×10^{-4}	6.21×10^{-4}
Bone Surfaces	3.21×10^{-3}	2.96×10^{-3}
Lung	(f)	(f)

WATER INGESTION $\left[\frac{\text{Rem * Milliliter}}{\text{Microcurie}}\right]$ a,c

Organ	Pu-239,-240	Am-241	U-233,-234	U-238
Effective Dose Equivalent	3.53×10^{6}	3.29×10^{6}	1.90×10^{5}	1.70×10^{5}
Liver	1.32×10^{7}	1.24×10^{7}	(e)	(e)
Bone Surfaces	6.42×10^{7}	5.91×10^{7}	2.99×10^{6}	2.70×10^{6}
Lung	(f)	(f)	(f)	(f)

GROUND-PLANE IRRADIATION $\left[\frac{\text{Rem * Square Meter}}{\text{Microcurie}}\right]$ d

Organ	Pu-239,-240	Am-241
Effective Dose Equivalent	4.80×10^{-5}	2.99×10^{-3}
Liver	4.53×10^{-6}	1.78×10^{-3}
Bone Surfaces	1.62×10^{-5}	3.69×10^{-3}
Lung	9.78×10^{-6}	2.01×10^{-3}

a. Inhalation, water, and soil ingestion dose conversion factors were adapted from DOE/EH-0071 (DOE88b) and are for a 50-yr dose commitment period and a 1-micrometer (μm) Activity Median Aerodynamic Diameter (AMAD) particle size. Gastrointestinal (GI) absorption fractions and lung clearance classes were chosen to maximize the dose conversion factors.
b. An inhalation rate of 2.66×10^2 milliliters per second (ml/s) for 1 yr was assumed and incorporated into the dose conversion factor.
c. A water intake rate of 2×10^3 ml (2.1 quarts) per day for 1 yr was assumed.
d. Ground-plane irradiation dose conversion factors were adapted from DOE/EH-0070 (DOE88a). For Pu-239 and -240, the higher of the factors for the two isotopes was used. A 1-yr exposure period was assumed.
e. The liver receives no significant dose from this pathway.
f. The lung receives no significant dose from this pathway.
g. A soil ingestion rate of 100 milligrams per day for 1 year was assumed and incorporated into the dose conversion factor.

Maximum Plant Boundary Dose

Dose assessment for 1991 was conducted for several locations: the RFP property boundary and sites to a distance of 80 kilometers (50 miles). DOE Order 5400.5 (DOE90a) requires that doses calculated for demonstration of compliance with applicable standards "...be as realistic as practicable. Consequently, all factors germane to dose determination should be applied. Alternatively, if available data are not sufficient to evaluate these factors or if they are too costly to determine, the assumed parametric values shall be sufficiently conservative so that it is unlikely that individuals would actually receive a dose that would exceed the dose calculated using the values assumed."

In previous annual RFP site environmental reports, the approach taken for dose assessment was extremely conservative based on assumptions for a hypothetical individual that would tend to maximize the resulting dose estimate; however, these assumptions were known to be unrepresentative of actual living habits in the RFP area. For example, it was assumed that the hypothetical member of the public was residing continuously during the year at the RFP boundary at the location for which the highest average plutonium in air concentration was measured for the year. The location might change from year to year, depending on where that maximum concentration was measured. The maximum plutonium and americium soil concentrations measured near the RFP boundary were used in calculating potential exposure from contaminated soil, even though no individual actually lived near the location for those maxima.

In this 1991 report, more realistic, but still conservative, assumptions are made for dose assessment in conformance with the DOE Order 5400.5 guidance. Environmental monitoring data are used from sample locations nearer areas of actual residence. The nearest housing to RFP is located near the southeast boundary of the plant. Sampling locations were chosen that are near this boundary but generally upwind or upgradient of existing housing, and between the housing and RFP processing facilities. Following is a description of the radionuclide concentrations (source terms) used for calculating the maximum radiation dose to the public for all pathways and the results of that calculation.

The soil ingestion source terms and the ground-plane source terms of penetrating radiation exposure from contaminated soil areas are based on measured concentrations of plutonium in soil and an assumed ratio of 0.20 for the americium-241 to plutonium-239, -240 activity. Inhalation source terms for the 1991 dose assessment were based on plutonium-239, -240 concentrations measured in ambient air samples. Although it is known that some of this plutonium in soil and air is from residual fallout from past global atmospheric weapons testing, for the purposes of this dose assessment it was conservatively assumed that all plutonium originated from RFP.

The maximum site boundary dose assessment assumes that an individual is present continuously at the RFP perimeter. This assumption of an individual residing continuously at the plant boundary is used to provide a conservative upper bound on any radiation dose to the public that might originate from RFP.

The plutonium inhalation source term of 1×10^{-18} $\mu Ci/ml$ (3.7×10^{-8} Bq/m^3) was the annual average concentration of plutonium-239 and -240, as measured at the S-38 location in the perimeter ambient air sampling network. The S-38 location is the closest plant perimeter air sampling location upwind of housing located nearest to the plant in the southeast direction. This housing is near the RFP boundary.

The water supply for a hypothetical individual at the RFP boundary was assumed to be Pond C-2, which receives surface water runoff and, potentially, some seepage of contaminated alluvial groundwater from RFP. Pond C-2 is intermittently discharged offsite. It should be noted that the assumption that someone may drink this water is extremely conservative, leading to an overestimate of dose to the individual. No individual uses Pond C-2 water effluent at its discharge point as a finished drinking water supply, and during 1991 no surface water effluent from RFP went directly to any drinking water supply. Plant surface water effluents were diverted around Great Western Reservoir and Standley Lake during 1991. Following diversion, these waters flowed from Walnut Creek to Big Dry Creek and subsequently to the South Platte River. The RFP contribution to total flow in the South Platte River would be less than approximately 0.2 percent based on South Platte River flow, as measured at the Henderson, Colorado, gaging station during water year 1991 (October 1990 - September 1991) (UG92).

Municipal water supplies near RFP do not serve residences nearest the plant. For these residences, drinking water is likely from well water or bottled water sources. Currently, it is believed that no offsite drinking water wells have been contaminated with radioactive materials as a result of RFP activities. Extensive characterization of background radioactivity concentrations in groundwater and the hydrogeology of RFP are in progress to verify this belief.

During 1991, plutonium concentrations in Pond C-2 averaged 1.3×10^{-11} µCi/ml (4.8×10^{-4} Bq/l). Average americium concentration was 8.0×10^{-12} µCi/ml (3.0×10^{-4} Bq/l). These concentrations were used as the water ingestion source term for the maximum individual dose assessment. Uranium-233, -234 average concentration in Pond C-2 was 8.5×10^{-10} µCi/ml (3.1×10^{-2} Bq/l) and the average concentration of uranium -238 in Pond C-2 was 1.0×10^{-9} µCi/ml (3.7×10^{-2} Bq/l). The average concentrations of uranium-233, -234, and uranium-238 in incoming raw water were 4.4×10^{-10} µCi/ml (1.6×10^{-2} Bq/l) and 3.7×10^{-10} µCi/ml (1.4×10^{-2} Bq/l), respectively. The source terms used for uranium ingestion were the difference between the Pond C-2 and raw water concentrations for each of the two uranium isotope categories: 4.1×10^{-10} µCi/ml (1.5×10^{-2} Bq/l) for uranium-233, -234, and 6.3×10^{-10} µCi/ml (2.3×10^{-2} Bq/l) for uranium-238. The average tritium concentration in Pond C-2 was 8.1×10^{-8} µCi/ml (3.0 Bq/l). Tritium is a relatively insignificant contributor to dose at such low concentrations because the radiation it emits is a very low energy beta radiation that has a relatively small dose conversion factor.

A potential exposure pathway added to the RFP radiation dose assessment for 1991 is direct ingestion of contaminated soil. Inclusion of this pathway is consistent with approaches to risk assessment suggested by the EPA in *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)* (EPA89b). An intake rate of 100 mg/day is assumed for this pathway. The plutonium-239, -240 in soil concentration from onsite sampling location 2-126 was taken as conservatively representative of soil for residences nearest RFP. Americium-241 was calculated to be 20 percent of the plutonium-239, -240 concentration, based on maximum ingrowth of americium-241 from plutonium-241 in typical RFP weapons-grade plutonium (DOE80). The 1991 measured plutonium-239, -240 concentration in soil at the 2-126 location is 0.25 pCi/g (9.3×10^{-3} Bq/g) (see Figure 3.5-1 and Table 3.5-1). The calculated americium-241 concentration is 0.05 pCi/g (1.9×10^{-3} Bq/g).

Ground-plane irradiation by external penetrating radiation from contaminated soil areas is included as a potential pathway of exposure, although it is a relatively small contributor to dose. External penetrating radiation associated with radioactive materials of importance at RFP is generally of low energy and intensity. The ground-plane irradiation source term used for this assessment is again based on the plutonium concentration in soil measured at the onsite 2-126 location and an assumed soil density of 1 gram per cubic centimeter (g/cm^3), and a sampling depth of 5 cm used to determine areal concentration. The plutonium-239, -240 areal source term is 1.3×10^{-2} $\mu Ci/m^2$ (4.6×10^2 Bq/m^2). The americium source term is estimated at 2.5×10^{-3} $\mu Ci/m^2$ (9.3×10^1 Bq/m^2).

Table 6-3 summarizes the radionuclide concentrations used for calculating the estimate of maximum radiation dose to an individual member of the public from all the identified potential pathways of exposure. From these concentrations and dose conversion factors given in Table 6-2, a 50-year dose commitment of 3.2×10^{-1} mrem (3.2×10^{-3} mSv) is calculated as the EDE from all pathways. The bone surfaces receive the highest calculated individual organ dose (Table 6-4). The bone surfaces dose is 5.3 mrem (5.3×10^{-2} mSv). The DOE radiation protection standard for members of the public for all pathways and for prolonged periods of exposure is 100 mrem/yr (1 mSv/yr) EDE. The maximum site boundary dose in 1991 represents 0.32 percent of the standard for all pathways for EDE.

Table 6-3
Radioactivity Concentrations Used in Maximum Site Boundary Dose Calculations for All Pathways for 1991

Air (μCi/ml)	Soil (pCi/g)		Surface Deposition (μCi/m²)		Water (μCi/ml)			
Pu-239,-240	Pu-239,-240	Am-241	Pu-239,-240	Am-241	Pu-239,-240	Am-241	U-233/-234	U-238
1.0×10^{-18}	2.5×10^{-1}	5.0×10^{-2}	1.3×10^{-2}	2.5×10^{-3}	1.3×10^{-11}	8.0×10^{-12}	4.1×10^{-10}	6.3×10^{-10}

Table 6-4
50-Year Committed Dose Equivalent from 1 Year of Chronic Intake/Exposure from the RFP in 1991

Location	Effective Dose Equivalent (mrem)	Liver (mrem)	Bone Surfaces (mrem)	Lung (mrem)
Maximum Site Boundary	3.2×10^{-1}	4.9×10^{-1}	5.3	1.6×10^{-2}

Radiation Dose from Air Pathway Only

EPA-approved methodology (EPA89a) is used to demonstrate compliance with CAA NESHAP standards for airborne radioactivity emissions. As of December 15, 1989, the EPA-approved standard is based on meteorological/dose modeling of air emissions using the AIRDOS-PC or CAP-88 computer codes. Table 6-5 lists the 1991 radioactivity air emissions used as input to the AIRDOS-PC computer code. These emissions include building air effluent release values for the year as discussed in Section 3.2 and an estimate of resuspension from soil from the 903 Pad area (OU 2). The estimated soil resuspension is included for comparison to the 1989 and 1990 RFP site environmental reports and for use in calculating collective population dose.

Table 6-5

Radionuclide Air Emissions for Input to AIRDOS-PC Computer Code 1991

Radionuclide(s)	Air Emission Activity (Ci)
Measured Building Emissions:	
H-3 (Tritium)	4.76×10^{-3}
Pu-238	2.96×10^{-8}
Pu-239, -240	8.43×10^{-7}
U-233, -234	6.29×10^{-7}
U-238	1.00×10^{-6}
Am-241	1.50×10^{-7}
Estimated Soil Resuspension:	
Pu-241	1.0×10^{-3}
Pu-239, -240	2.0×10^{-4}
Am-241	4.1×10^{-5}
Pu-238	4.8×10^{-6}

The RFP annual site environmental reports for 1989 and 1990 included an estimate of 903 Pad area soil resuspension that was developed in the RFP EIS, published in 1980 (DOE80). More recent field studies completed by RFP indicate that the EIS-estimated soil resuspension rate is likely to be considerably higher than is actually occurring, leading to a greatly conservative overestimate of radiation dose to the public using the EIS values. The soil resuspension source term used in the 1991 radiation dose assessment and listed in Table 6-5 is based on the more recent RFP field studies and is considered a more realistic estimate of resuspension (LA91).

Meteorological input data for 1991, which was reformatted as required for input to the AIRDOS- PC calculations, is given in Tables C1 through C7, Appendix C.

AIRDOS-PC default values for lung clearance class and gastrointestinal uptake fractions were used when running the code. The AIRDOS-PC default assumption of a 1-µm activity median aerodynamic diameter (AMAD) particle size also was used.

The AIRDOS-PC computer code calculated an EDE from measured building air emissions of 4.4×10^{-5} mrem (4.4×10^{-7} mSv) to the maximally exposed individual residing approximately 2.45 miles from the plant emissions points. The EDE from estimated soil resuspension was calculated as 9.3×10^{-3} mrem (9.3×10^{-5} mSv) to the maximally exposed individual residing approximately 2.1 miles from the 903 Pad area.

Collective Population Dose

DOE Order 5400.5, promulgated February 8, 1990, requires the assessment of collective population radiation dose to a distance of 80 kilometers (50 miles) from the center of a DOE facility (DOE90a). The assessment of maximum community dose (i.e., maximum dose to an individual in a neighboring community) that was presented in RFP annual site reports prior to 1990 is no longer included in the DOE approach to radiation dose assessment.

Collective population dose is calculated as the average radiation dose to an individual in a specified area, multiplied by the number of individuals in that area. In assessing the 1991 collective population dose to the public within a radius of 50 miles of RFP, the assessment was limited to airborne emissions of radioactive materials from the plant as the major contributor to population dose. Only two public raw water supplies, Great Western Reservoir and Standley Lake, can receive water directly from drainages crossing RFP, and all surface water effluent from RFP was diverted around these water supplies during 1991. Soil contamination decreases rapidly with distance from the RFP. In addition, most residential areas within this radius are likely to have new topsoil, sod, or otherwise modified soil conditions; agricultural areas represent a relatively small population.

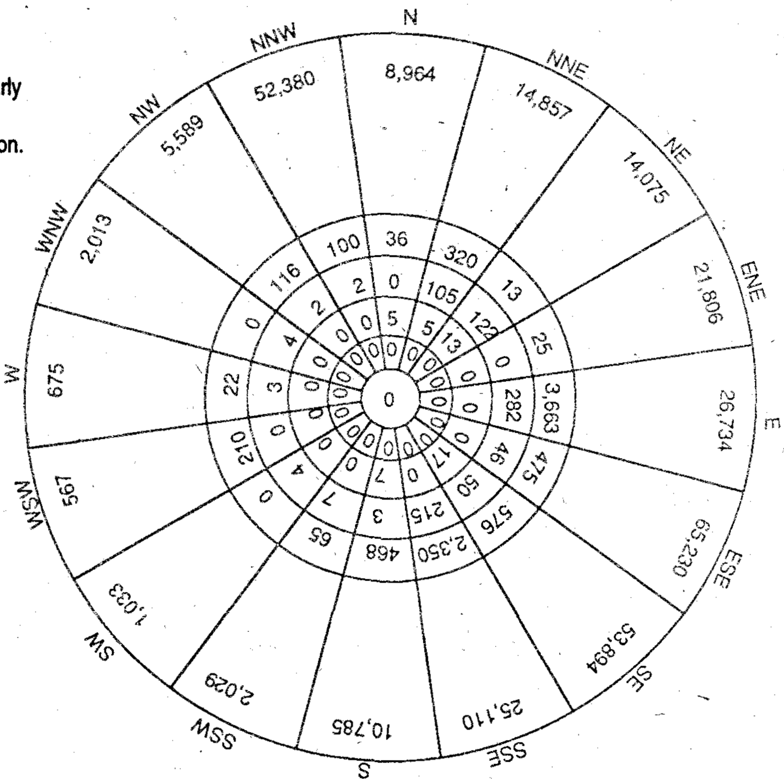
Population estimates provided by the Denver Regional Council of Governments (DRCOG), the State of Colorado, and some local municipalities near RFP were used to determine the 1991 population residing within 50 miles of RFP. An area defined by a circle of 50-mile radius around the center of RFP was further divided into 16 equal sectors, with segments formed by the intersection of the sectors and a total of 10 radial distances of 1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles (see Figure 6-1). The population within each segment for 1991 was based on 1990 U. S. census data and growth projections furnished by DRCOG, the State of Colorado, and local municipalities. In addition, for segments within a 10-mile radius, segment populations were determined using the *1989 Population, Economic, and Land Use Database for Rocky Flats Plant* (DOE90b) to modify population distributions. This was necessary because even the census tract data of DRCOG lacked the necessary spatial resolution of reasonable segment population estimates at distances near to RFP.

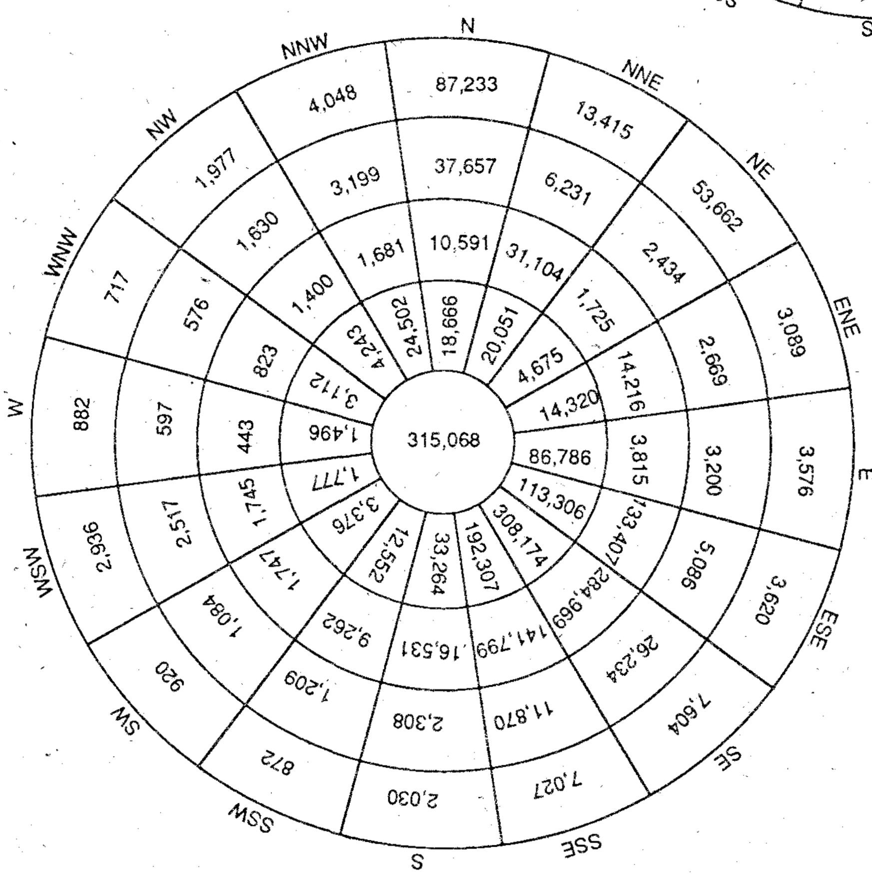
The estimates of 1991 segment populations are given in Figure 6-1. Because the census-based estimates are for political jurisdictions that do not correspond to the geographical boundaries of the segments, the population estimates of Figure 6-1 should be considered approximations only. Total population for the area within a radius of 50 miles for 1991 was estimated at 2.1 million people.

The EPA atmospheric dispersion/radiation dose calculation computer code AIRDOS-PC was used to calculate the average radiation dose to an individual within each population segment. AIRDOS-PC is the same computer code that is used by RFP to demonstrate compliance with CAA NESHAP requirements, as promulgated at 40CFR61, Subpart H (EPA89a). Meteorological data that were collected for RFP during 1991, as well as measured building air effluent radioactivity data and estimates of soil resuspension radioactivity, were used as input to the AIRDOS-PC code. EDEs were calculated by AIRDOS-PC to the midpoint

These population estimates were calculated from 1990 census tract data adjusted for yearly change through 1991, assuming uniform population distribution throughout each section.

Concentric circles represent 1- to 2-, 2- to 3-, 3- to 4-, 4- to 5-, and 5- to 10-mile bands.





Concentric circles represent 10- to 20-, 20- to 30-, 30- to 40-, 40- to 50-mile bands.

Figure 6-1. 1991 Demographic Estimates for Areas 0 - 10 and 10 - 50 Miles from the RFP

of each segment's radial distance. These EDEs were used as estimates of the average radiation dose to an individual residing within the segment.

Multiplying the population (number of persons) within a segment by the average individual dose (in rem or sieverts, 1 Sv = 100 rem) within the segment results in a calculated collective population dose for each segment in units of person-rem (or person-Sv). The total person-rem for all segments is the collective population dose for a distance of 50 miles around RFP, as presented in Table 6-6 for 1991. The collective population dose within 50 miles of RFP was calculated as 0.9 person-rem (0.9×10^{-2} person-Sv). Significantly, the majority of this collective population dose results from estimated contaminated soil resuspension from the 903 Pad area of RFP. A very small contribution (5×10^{-3} person-rem [5×10^{-5} person-Sv]) is attributable to measured building air emissions for 1991.

Natural Background Radiation Dose

EDEs from RFP may be compared to an average annual EDE for the Denver area of about 350 mrem (3.5 mSv) from natural background radiation (NA87b) (Table 6-7). Natural background radiation for Denver is higher than shown for the total body in RFP annual reports prior to 1985 and also higher than shown for EDE in the 1985 and 1986 annual reports. The level reflects the most recent assessment of natural background radiation exposure of the population of the United States by the NCRP. It includes the significant contribution to EDE from inhaled indoor radon, as well as the adoption of the ICRP 30 methodology of radiation dosimetry. Cosmic radiation and external primordial nuclides sources shown in Table 6-7 reflect the regional dose levels for the Denver area from the higher elevation and greater concentration of naturally occurring uranium and thorium in soil. The internal primordial nuclides source includes the average dose from indoor radon estimated by the NCRP for the entire United States. Investigations are now being conducted to determine whether any regional differences in indoor radon doses exist. Once these studies are completed and published, the estimates of natural background radiation dose for the Denver area may be modified to reflect indoor radon doses specific to this region.

Table 6-6
1991 Calculated Radiation Dose to the Public from 1 Year of Chronic Intake/Exposure from the RFP

MAXIMUM INDIVIDUAL DOSE:	
All Pathways[a]	3.2×10^{-1} mrem (3.2×10^{-3} mSv) Effective Dose Equivalent (EDE)
Measured building air emissions[b]	4.4×10^{-5} mrem (4.4×10^{-7} mSv) EDE
Estimated soil resuspension[c]	9.3×10^{-3} mrem (9.3×10^{-5} mSv) EDE
COLLECTIVE POPULATION DOSE TO 80 km (50 mi):	
Measured building air emissions[b]	5×10^{-3} person-rem (5×10^{-5} person-Sv) EDE
Estimated soil resuspension[c]	0.9 person-rem (0.9×10^{-2} person-Sv) EDE
Total	0.9 person-rem (0.9×10^{-2} person-Sv) EDE
ESTIMATED TOTAL POPULATION WITHIN 80 km (50 mi):[d]	2.1×10^{6} persons
DOE RADIATION PROTECTION STANDARDS FOR THE PUBLIC:[e]	
All Pathways[f]	100 mrem (1 mSv) EDE, normal operations 500 mrem (5 mSv) EDE, temporary increase (only with priorapproval of DOE EH-2)
Air Pathway only[g]	10 mrem (1×10^{-1} mSv) EDE
ESTIMATED ANNUAL NATURAL BACKGROUND INDIVIDUAL RADIATION DOSE FOR THE DENVER METROPOLITAN AREA:	350 mrem (3.5 mSv) EDE
ESTIMATED ANNUAL NATURAL BACKGROUND COLLECTIVE POPULATION DOSE WITHIN 80 km (50 mi):	7×10^{5} person-rem (7×10^{3} person-Sv) EDE

a. Calculated using environmental monitoring input data.
b. Calculated using AIRDOS-PC modeling of measured building air emissions.
c. Calculated using AIRDOS-PC modeling of estimated soil resuspension from the 903 Pad area.
d. Based on estimates from information provided by the State of Colorado, the Denver Regional Council of Governments, and local municipalities.
e. From DOE Order 5400.5. Excludes medical sources, consumer products, residual fallout from past nuclear accidents and weapons tests, and naturally occurring radiation sources (DOE90a).
f. Based on recommendations of the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP).
g. Based on EPA Clean Air Act National Emission Standards for Hazardous Air Pollutants.

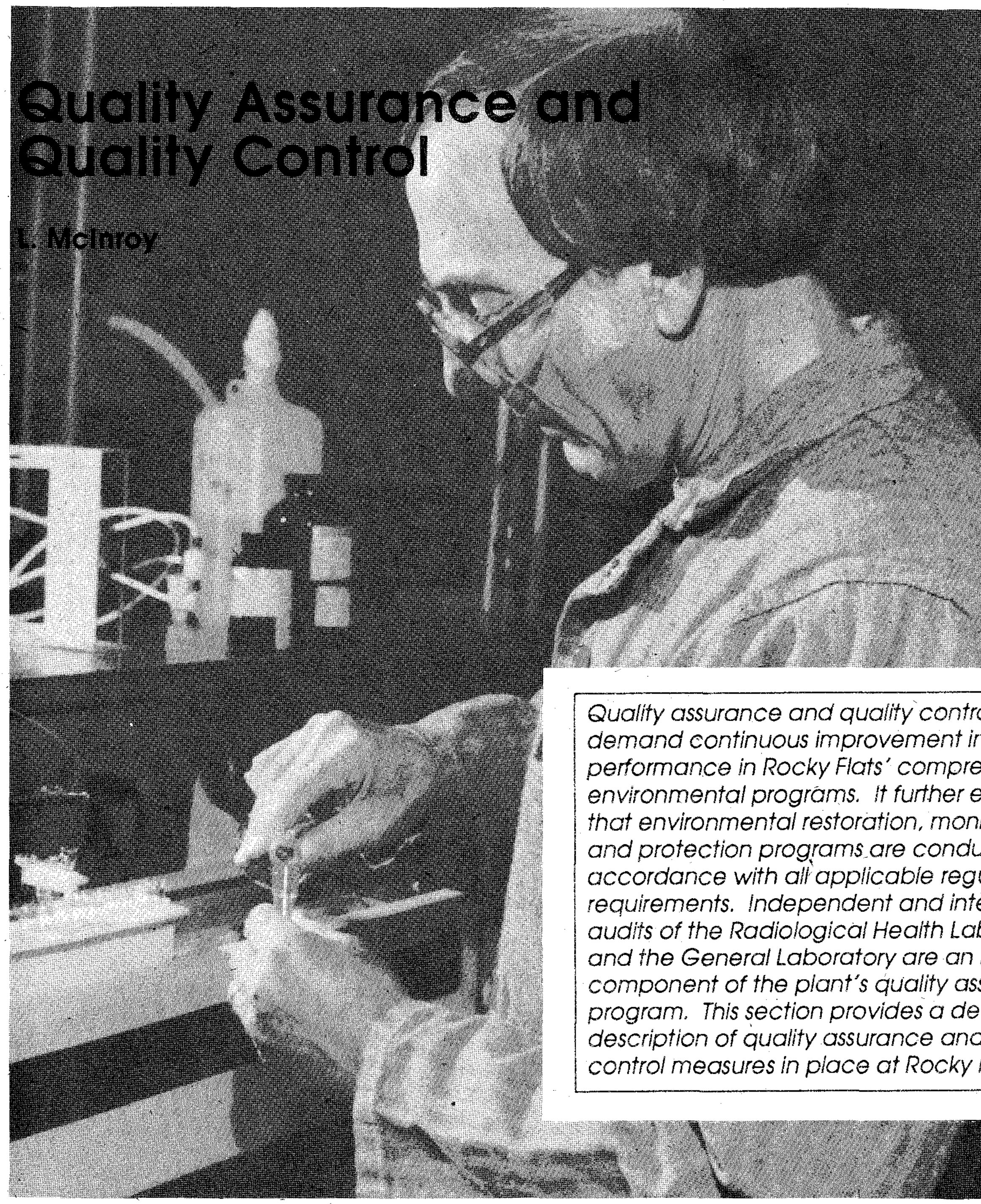
Table 6-7
Estimated Annual Natural Background Radiation Dose for the Denver Metropolitan Area (NA87b)

Source	Effective Dose Equivalent (mrem)
Cosmic Radiation[a]	50
Cosmogenic Nuclides	1
Primordial Nuclides - External[b]	63
Primordial Nuclides - Internal[c]	239
Total for 1 Year (rounded)	353

a. Includes regional increase over U.S. average as a result of the greater elevation of the Denver area.
b. Includes regional increase over U.S. average as a result of the higher concentrations of uranium and thorium in soil in the Denver area.
c. Includes U.S. average indoor radon dose contribution. This value likely will increase when regional indoor radon differences for the Denver area are determined.

7. Quality Assurance and Quality Control

L. McInroy



Quality assurance and quality control demand continuous improvement in performance in Rocky Flats' comprehensive environmental programs. It further ensures that environmental restoration, monitoring, and protection programs are conducted in accordance with all applicable regulatory requirements. Independent and internal audits of the Radiological Health Laboratory and the General Laboratory are an integral component of the plant's quality assurance program. This section provides a detailed description of quality assurance and quality control measures in place at Rocky Flats.

QUALITY ASSURANCE REQUIREMENTS

QA requirements that are applicable to environmental management activities at the RFP include those established by the DOE, RFP, and EPA. DOE Order 5400.1, *General Environmental Protection Program*, has established QA requirements that apply to all DOE environmental monitoring and surveillance programs. The *Rocky Flats Quality Assurance Manual* (RF QAM) consists of 22 quality requirements that are potentially applicable to all RFP programs, including environmental management programs. Both DOE Order 5400.1 and the RF QAM include by reference the QA requirements of DOE Order 5700.6B, *Quality Assurance*. DOE Order 5700.6B endorses the 18 QA criteria and supplemental requirements of the *American Society of Mechanical Engineers NQA-1, Quality Assurance for Nuclear Facilities* (ASME89). The RFP IAG requires DOE to prepare and implement a QA Project Plan for the environmental restoration program activities specified in the IAG that incorporates the 16 quality elements of EPA *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans* (EPA80).

ENVIRONMENTAL MANAGEMENT QA PROGRAM

The Environmental Management (EM) Department initiated development of a comprehensive QA Program for EM activities in 1990. The EM QA Program that has been developed identifies the QA requirements that apply to EM programs and projects and establishes methods, controls, and responsibilities for meeting those requirements. The EM QA program integrates quality requirements established by DOE, RFP, and the EPA. Previously, QA requirements and responsibilities set forth in the RFP Non-Weapons Quality Assurance Plan were applicable to EM programs.

The current EM QA Program consists of (1) the Quality Assurance Plan Description (QAPD) (EG92d), (2) the RFP Sitewide Quality Assurance Project Plan (QAPjP) for CERCLA Remedial Investigations/ Feasibility Studies and RCRA Facility Investigations/ Corrective Measures Studies Activities (EG91e), and (3) EM Administrative and Operating Procedures. The requirements, methods, controls, and responsibilities established in the QAPD apply to all EM programs and projects, whereas those established in the QAPjP apply only to RFP environmental restoration program activities that are required by the IAG (the QAPjP was prepared in addition to the QAPD because it is a deliverable specified in the IAG). The EM administrative procedures provide administrative controls and direction for the performance of a program, project, or activity. The EM operating procedures provide controls and direction for performance of routine operations and for the collection and analysis of environmental samples, which generate environmental measurement data. These procedures include the Standard Operating Procedures that are developed to implement the environmental restoration program and are submitted to the EPA and CDH for review and approval, which together with the QAPjP comprise the sampling and analysis plan for the RFP environmental restoration program.

The QAPjP was approved by the EPA and CDH in June 1991. The first draft of the QAPD was revised significantly during 1991 based on review and guidance from the EG&G Rocky Flats QA Organization. The revised QAPD received concurrence from the Assistant General Managers of the Environmental & Waste Management and the QA Organizations in December 1991; it was approved on January 23, 1992.

The QAPjP is supplemented by QA Addenda (QAA) that are prepared for each environmental restoration program work plan. QAA specify any additional quality requirements, quality controls, and methods that are specific to the work activities addressed by the respective work plan. QAA also address project-specific data quality objectives and reference applicable operating procedures. During 1991, 15 QAA were submitted to EPA and CDH for review. Seven of those 15 have been approved, and the others are in the review and/or comment response stage. Three additional QAA for treatability studies were prepared and approved by project managers.

As a result of developing the EM QA Program, the potential need for preparing and implementing 66 administrative procedures and 119 operating procedures has been recognized. During 1991, 10 of the administrative procedures were approved and 30 others were drafted and are in various stages of review. Of the 119 proposed operating procedures, 85 were approved during 1991 and 29 others were drafted and are in various stages of review. The EM administrative procedures (3-21000-ADM and 1-21000-ERM) and operating procedures (5-21000-OPS) have been proposed, drafted, and approved.

Quality Assurance Implementation Verification

Implementation of QA Program requirements, controls, and methods is verified by conducting internal readiness reviews, surveillances, and oversight inspections of EM program and project work activities. Internal QA verification activities are performed by EM or contractor personnel who are independent of the work activities being conducted. In addition to these internal verification activities, the EG&G Rocky Flats QA Organization conducts independent audits of EM programs and projects.

During 1991, approximately 130 internal oversight inspections of environmental restoration activities were conducted under the direction of the Remediation Programs Division Quality Coordinator. The activities of 16 subcontractors were inspected to ensure that activities were being conducted in compliance with the requirements and specifications of the QAPjP, QAA, work plans, and operating procedures. Inspections consisted of observations of the activities being performed and examination of the records generated by the activity. These oversight inspections were performed in the field at sampling and test sites, at the main decontamination facility, and at the subcontractors' field trailers. Following is a list of activities that were inspected.

- Collecting geotechnical, hydrologic, and ecological environmental samples
- Augering, drilling, and coring
- Trenching
- Logging and handling geotechnical materials
- Handling, labeling, containerizing, preserving, and shipping samples
- Tracking (sample chain-of-custody) samples

- Installing monitoring wells and piezometers
- Field surveying
- Field analysis and generating field measurement data
- Radiological screening of environmental samples
- Documenting samples
- Decontaminating general and heavy equipment
- Collecting and/or preparing quality control sample blanks
- Calibrating instruments and recording calibration
- Storing samples
- Using and maintaining current work plans, procedures, and forms
- Record keeping and managing data

The primary activities inspected included those conducted at Operable Units 1 and 2 (881 Hillside and 903 Pad, Mound, and East Trenches, respectively), sitewide geologic characterization studies, and baseline ecological field investigations. Inspection checklists were used to conduct the inspections, and the results of each inspection were documented on an Environmental Management Inspection Report.

In 1991, five readiness reviews were conducted on EM activities. Readiness reviews are performed to determine whether a planned project or work activity is ready to proceed. Readiness reviews are performed under the direction of the Quality Assurance Program Manager (QAPM), who selects a readiness review team leader and a readiness review team. The leader prepares a readiness review checklist, which consists of applicable work activity prerequisites, requirements, and other pertinent information that provides evidence for determining readiness. The checklist is then used to document the readiness to proceed with the project or work activity.

Readiness reviews were conducted before the following EM projects began.

- Operable Unit 1 (881 Hillside) Phase III RFI/RI
- Phase IIA Construction of the 881 Hillside Groundwater Treatment System

- Operable Unit 2 (903 Pad, Mound, and East Trenches) Phase II RFI/RI
- Construction and System Testing of the South Walnut Creek Surface Water Granular Activated Carbon Treatment Unit
- Operation of the Main Decontamination Pad

After the above listed projects began, an internal QA surveillance was performed for each project under the direction of the QAPM. In addition to the above listed projects, a surveillance was also conducted of drilling and field sampling activities associated with the environmental restoration program. These surveillances consisted of observing project work activities to verify that they were being conducted according to the QA requirements specified in the QAPjP, QAA (as appropriate), and project work plans. The result of each surveillance is documented in a report prepared by the surveillance team leader. The surveillance report documents observations, deficiencies, and recommendations.

The EG&G Rocky Flats QA Organization conducted an independent audit of the EM QA Program in 1991 to verify that the program complies with RFO requirements.

RADIOLOGICAL HEALTH LABORATORIES

The QA practices currently operative within the RFP Radiological Health Laboratories (RHL) QA/QC program include the following elements.

- Development, preparation, revision, issue, and control of all laboratory procedures and documents according to the RFP/NQA-1 Document Control System.
- Scheduled instrument calibration, control charting, and preventive maintenance.
- Scheduled analytical process control charting, trend analysis, out-of-control actions, and recurrence control.
- Participation in interlaboratory quality comparison programs.
- Intralaboratory quality control programs.

All environmental field samples received for analysis by the RHL are configured into Quality Control (QC) Sample Batches, which consist of a group of twelve or fewer samples that include duplicate internal matrix surrogate controls, matrix blank, and any interlaboratory control standards. Each set of samples (blank and controls) comprise a QC Batch and is assigned a unique QC batch number. Each sample can be correlated with, and traced to, its corresponding batch. The statistical evaluation of the defined control sample parameters determine the acceptability of the sample batch data relative to the data quality specifications (data quality objectives) agreed upon with the customer. If any samples require reanalysis, they are included in another QC batch.

A sample analysis or QC Batch may be rejected and the sample or batch scheduled for reanalysis for one or more of the following reasons.

- Overall chemical recovered of the internal standard for any sample analysis is < 10 percent or > 105 percent.
- A QC batch fails one or more of the customer agreed upon data quality criteria for accuracy, precision, or sensitivity.
- A sample alpha energy spectrum is not acceptable because of extra and/or unidentified peaks, excess noise in background areas, or poor resolution of peaks.
- The chemist in charge has reason to suspect the analysis because of historical knowledge or indications of sample and control mixup.

Any unusual condition affecting the results, noted during sample collection, analysis, or QA review, is reported to the appropriate management officials. Quality Assurance provides written notification to management to suspend any analytical operation, pending review and corrective actions, when process control charts or other statistical evaluations indicate that the process is out of control.

The RHLs participate in the EPA Environmental Monitoring Systems Laboratory and the DOE Environmental Measurements Laboratory (EML) crosscheck programs. Table 7-1 summarizes the RHLs' participation in this program for 1991.

Table 7-1
Radiological Health Laboratories' Participation in the EPA Environmental Monitoring Systems Laboratory Crosscheck Program During 1991

Isotope Reported	Matrix	Method	Number of Analyses	Number of Acceptable Analyses[a]	Annual Relative Error Percent[b]	Range of Relative Error Percent
Gross Alpha	Filter	Gas Proportional	1	1	40	N/A
H-3 (Tritium)	Water	Beta Liquid Scintillation	2	2	5.3	0.9 to 9.6

a. "Acceptable analyses" are those analyses for which the observed value was within ± 3 standard deviations of the standard value.
b. The mean of the ratio of the 12-month differences between observed and standard values to standard values in percent. This term is inclusive of all random and systematic error in the standards, analytical chemistry, and measurement process for a given nuclide, matrix, and procedure.

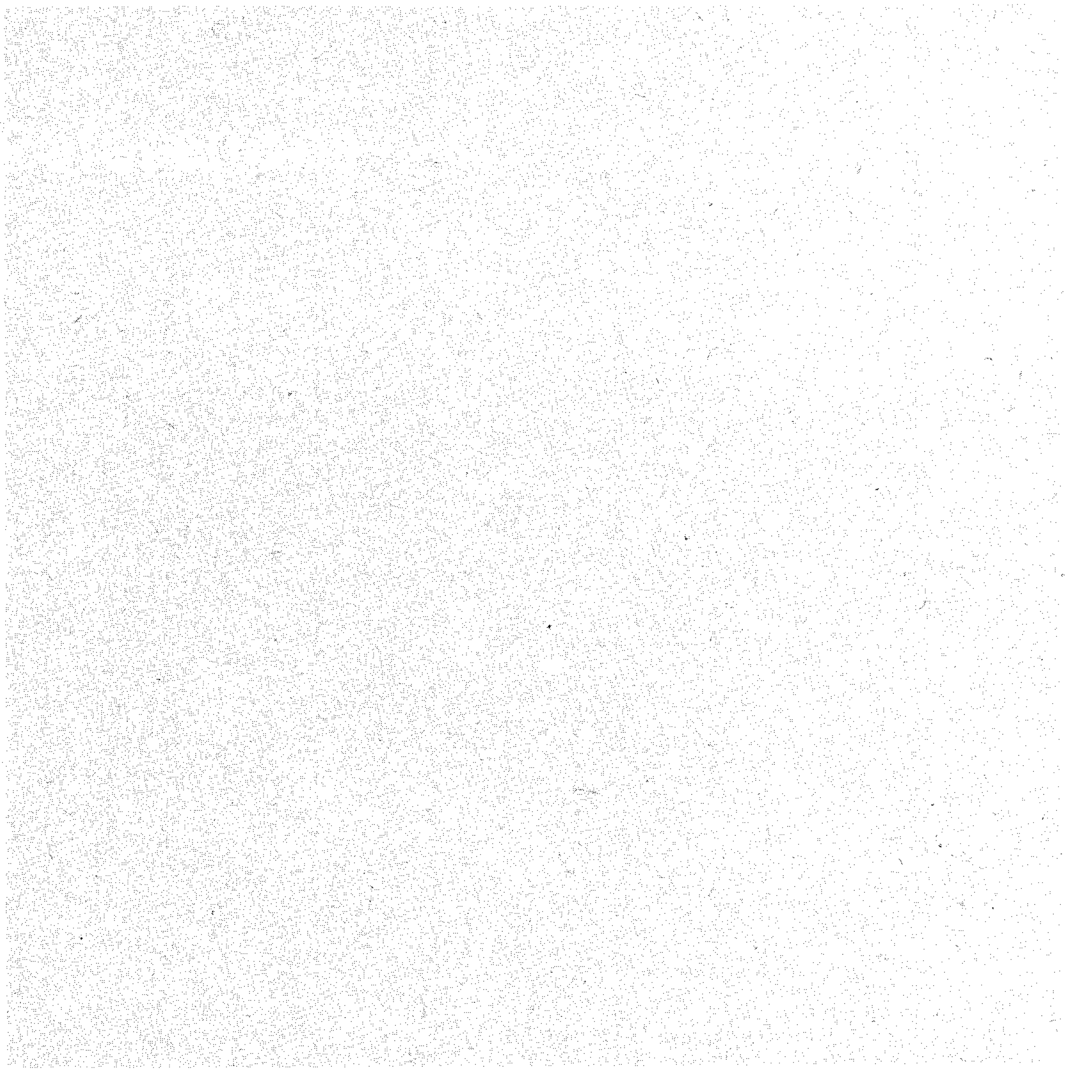
GENERAL LABORATORY

The Analytical Laboratories Quality Assurance Plan provides comprehensive guidance to the General Laboratory to ensure data quality. The laboratory organization, functions, responsibilities, policies, and programs that comprise the overall QA program are described. Following are highlights of the program.

- Staff qualification and training
- Analytical procedure development, control, and compliance
- Laboratory records and sample handling protocols
- Analytical instrument calibration and maintenance
- Reagent purity and standardization
- Measurement control and data review
- Self-appraisals and corrective actions

Detailed quality control for the reliability of analytical data is provided in each General Laboratory analytical operating procedure. Typically, samples are analyzed in daily batches containing approximately 25 percent control samples. Control samples consist of various blanks, duplicates, standards, and spikes. This batching of samples and controls ensures reproducible, quality measurements. Traceable standards are prepared both within and independently of the laboratory. Reportability of data is judged by (1) the behavior of batch control samples, and (2) the responsible chemist and QA officer.

The General Laboratory participates in a number of independent blind sample programs to control and assess analytical measurements. More than 125 blind samples are submitted monthly to the General Laboratory for the RFP Interactive Measurement Evaluation and Control System. This program provides immediate feedback on analyses as well as monthly reports and meetings to review analytical results. Performance samples from the EPA for the NPDES program are analyzed and evaluated annually. Environmental samples from the United States Geological Survey (USGS) are evaluated biannually. The laboratory participates in radiochemistry programs conducted by the EPA Environmental Monitoring Systems Laboratory and the DOE EML. The General Laboratory also purchases (from an independent commercial laboratory) a suite of water samples for a quarterly program administered by the laboratory QA officer.



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9. Useful Information

ABBREVIATIONS

Units of Measure

Bq	Becquerel
Bq/l	Becquerel per liter
Bq/m^2	Becquerel per square meter
Bq/m^3	Becquerel per cubic meter
°C	Degree Celsius
Ci	Curie
Ci/g	Curie per gram
cm	Centimeter
cm^3	Cubic centimeter
d/m/µCi	Disintegration per minute per microcurie
d/m/pCi	Disintegration per minute per picocurie
d/m/f	Disintegration per minute per filter
d/m/l	Disintegration per minute per liter
dpm/g	Disintegration per minute per gram
dps	Disintegration per second
°F	Degree Fahrenheit
ft^2	Square Foot
ft^3/min	Cubic foot per minute
fpm	Foot per mile
g	Gram
gal	Gallon
g/cm^2	Gram per square centimeter
g/day	Gram per day
gpm	Gallon per minute
ha	Hectare
kg	Kilogram
km	Kilometer
l	Liter
l/d	Liter per disintegration
l/s	Liter per second
lb	Pound
m^2	Square meter
m^3	Cubic meter
m^3/s	Cubic meter per second
mg/cm^2	Milligram per square centimeter
mg/l	Milligram per liter
ml	Milliliter
ml/day	Milliliter per day
ml/s	Milliliter per second
mph	Mile per hour
mrem	Millirem
mrem/day	Millirem per day

mrem/yr	Millirem per year
m/s	Meter per second
m^3/s	Cubic meter per second
mSv	Millisievert
mSv/yr	Millisievert per year
μCi	Microcurie
$\mu Ci/m^2$	Microcurie per square meter
μCi/ml	Microcurie per milliliter
μg	Microgram
μg/f	Microgram per filter
μg/l	Microgram per liter
$\mu g/m^3$	Microgram per cubic meter
μg/ml	Microgram per milliliter
pCi	Picocurie
pCi/g	Picocurie per gram
pCi/l	Picocurie per liter
ppb	Part per billion
ppm	Part per million
pt	Pint
%	Percent
rem	Roentgen equivalent man
rem/yr	Roentgen equivalent man per year
s	second
SI	International Standard
Sv	Sievert
yd^3	Cubic yard

Chemical Elements and Compounds

Am	Americium
Ba	Barium
Be	Beryllium
Ca	Calcium
CCl_4	Carbon Tetrachloride
Cl	Chlorine
Cm	Curium
CO	Carbon Monoxide
Co	Cobalt
Cr	Chromium
Cs	Cesium
Fe	Iron
H-3	Hydrogen-3 (Also called Tritium)
Mg	Magnesium
Mn	Manganese
Mo	Molybdenum
N	Nitrogen
Na	Sodium
NO_2	Nitrogen Dioxide
NO_3	Nitrate
O_3	Ozone
Pb	Lead
PCB	Polychlorinated Biphenyls
PCE	Tetrachloroethene
Pu	Plutonium
Ru	Ruthenium
Se	Selenium
SO_2	Sulfur Dioxide
SO_4	Sulfate
Sr	Strontium
TCA	1,1,1 - Trichloroethane
TCE	Trichloroethene
Tm	Thulium
U	Uranium
Zn	Zinc

ACRONYMS AND INITIALISMS

ADM	Action Description Memorandum
AEC	Atomic Energy Commission
AIP	Agreement In Principle
AMAD	Activity Median Aerodynamic Diameter
ANSI	American National Standards Institute
APEN	Air Pollutant Emission Notice
AQCC	Air Quality Control Commission
ARAR	Applicable or Relevant and Appropriate Requirement
ASME	American Society of Mechanical Engineers
BAT	Best Available Technology
BOD_5	Biochemical Oxygen Demand, 5-day incubation period
BRAP	Baseline Risk Assessment Plan
CAA	Clean Air Act
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMS/FS	Corrective Measures Study/Feasibility Study
CPDWR	Colorado Primary Drinking Water Regulations
CRP	Community Relations Plan
CWA	Clean Water Act
CWQCC	Colorado Water Quality Control Commission
CX	Categorical Exclusion
DCG	Derived Concentration Guide
DMR	Discharge Monitoring Report
DOE	Department of Energy
DOE-HQ	Department of Energy Headquarters
DRCOG	Denver Regional Council of Governments
EA	Environmental Assessment
EC	Environmental Checklist
EcMP	Ecological Monitoring Program
EDE	Effective Dose Equivalent
EE	Environmental Evaluation
EIS	Environmental Impact Statement
EM	Environmental Management
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ER	Environmental Remediation
ERDA	Energy Research and Development Administration

FFCA	Federal Facilities Compliance Agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	Finding of No Significant Impact
FSP	Field Sampling Plan
FYP	Five-Year Plan
GAC	Granular Activated Carbon
GI	Gastrointestinal
H&S	Health and Safety
HEPA	High Efficiency Particulate Air
HQ	Headquarters
IAG	Inter-Agency Agreement
ICP	Inductively Coupled Plasma
ICRP	International Commission on Radiological Protection
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measures/Interim Remedial Action
LDR	Land Disposal Restrictions
LEPC	Local Emergency Planning Committee
LLW	Low-level Waste
MAP	Mitigation Action Plan
MDA	Minimum Detectable Amount
MDL	Minimum Detection Limit
MSDS	Material Safety Data Sheet
NAAQS	National Ambient Air Quality Standards
NCC	NEPA Compliance Committee
NCRP	National Council on Radiation Protection and Measurements
NDA	Non-Destructive Assay
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NOI	Notice of Intent
NOID	Notice of Intent to Deny
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NQA1	Nuclear Quality Assurance
NRC	Nuclear Regulatory Commission; National Response Center
OPWL	Original Process Waste Lines
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Act
OU	Operable Unit
PA	Protected Area
PEIS	Programmatic Environmental Impact Statement
PM-10	Particulate Matter less than 10 micrometers in diameter
PPCD	Plan for Prevention of Contaminant Dispersion

PRMP EIS	Plutonium Recovery Modification Project Environmental Impact Statement
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAMS	Quality Assurance Management Staff
QAPD	Quality Assurance Program Description
QAPjP	Quality Assurance Project Plan
QAPM	Quality Assurance Program Manager
QAPP	Quality Assurance Program Plan
QAR	Quality Assurance Requirements
QC	Quality Control
RACT	Reasonable Available Control Technology
RCRA	Resource Conservation and Recovery Act
RDLWP	Radionuclides Discharge Limits Work Plan
RFI/RI	RCRA Facility Investigations/Remedial Investigations
RFO	Rocky Flats Office
RFP	Rocky Flats Plant
RFQAM	Rocky Flats Quality Assurance Manual
RHL	Radiological Health Laboratories
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPP	Resource Protection Program
RS	Responsiveness Summary
SAAM	Selective Alpha Air Monitor
SARA	Superfund Amendment and Reauthorization Act
SARF	Supercompactor and Repackaging Facility
SDWA	Safe Drinking Water Act
SERC	State Emergency Response Commission
SI	International Standard
SOP	Standard Operating Procedure
SOW	Statement of Work
SPCC/BMP	Spill Prevention Control and Countermeasures/Best Management Practices
SSP	Site-Specific Plan
STP	Sewage Treatment Plant
SU	Standard Units
SWMU	Solid Waste Management Unit
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solid
TLD	Thermoluminescent Dosimeter
TRG	Technical Review Group
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSP	Total Suspended Particulates
TSWP	Treatability Study Work Plan

USGS	United States Geological Survey
VOC	Volatile Organic Compound
WET	Whole Effluent Toxicity
WSRIC	Waste Stream and Residue Identification and Characterization
WWTP	Waste Water Treatment Plant

GLOSSARY

activity. See radioactivity.

air pollutant. Any fume, smoke, particulate matter, vapor, gas, or combination thereof that is emitted into or otherwise enters the atmosphere, including, but not limited to, any physical, chemical, biological, radioactive (including source material, special nuclear material, and by-product materials) substance, or material, but does not include water vapor or steam condensate.

aliquot. Of, pertaining to, or designating an exact divisor or factor of a quantity, especially of an integer.

alpha particle. A positively charged particle emitted from the nucleus of an atom having the same charge and mass as that of a helium nucleus (2 protons, 2 neutrons).

atom. Smallest particle of an element capable of entering into a chemical reaction.

beta particle. A negatively charged particle emitted from the nucleus of an atom having a mass and charge equal to that of an electron.

concentration. The amount of a specified substance or amount of radioactivity in a given volume or mass.

contamination. The deposition of unwanted radioactive or hazardous material on the surfaces of structures, areas, objects, or personnel.

cosmic radiation. Radiation of many types with very high energies, originating outside the earth's atmosphere. Cosmic radiation is one source contributing to natural background radiation.

curie (Ci). The traditional unit for measurement of radioactivity based on the rate of radioactive disintegration. One curie is defined as 3.7 X 1010 (37 billion) disintegrations per second. Several fractions and multiples of the curie are in common usage.

> **millicurie (mCi).** 10^{-3} Ci, one-thousandth of a curie; 3.7×10^{7} disintegrations per second.
>
> **microcurie (µCi).** 10^{-6} Ci, one-millionth of a curie; 3.7×10^{4} disintegrations per second.
>
> **nanocurie (nCi).** 10^{-9} Ci, one-billionth of a curie; 37 disintegrations per second.

picocurie (pCi). 10^{-12} Ci, one-trillionth of a curie; 3.7 x 10^{-2} disintegrations per second.

femtocurie (fCi). 10^{-15} Ci, one-quadrillionth of a curie; 3.7 x 10^{-5} disintegrations per second.

attocurie (aCi). 10^{-18} Ci, one-quintillionth of a curie; 3.7 x 10^{-8} disintegrations per second.

decay, radioactive. The spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

Derived Concentration Guide (DCG). Secondary radioactivity in air and water concentration guides used for comparison to measured radioactivity concentrations. Calculation of DCG assumes that the exposed individual inhales 8,400 cubic meters of air per year or ingests 730 liters of water per year at the specified radioactivity DCG with a resulting radiation dose of 0.1 rem (100 mrem) EDE.

disintegration, nuclear. A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus of an atom.

dose, absorbed. The amount of energy deposited by radiation in a given mass of material. The unit of absorbed dose is the rad or the gray (1 gray = 100 rad).

dose commitment. The total radiation dose projected to be received from an exposure to radiation or intake of radioactive material throughout the specified remaining lifetime of an individual. In theoretical calculations, this specified lifetime is usually assumed to be 50 years.

dose equivalent. A modification to absorbed dose that expresses the biological effects of all types of radiation (e.g., alpha, beta, gamma) on a common scale. The unit of dose equivalent is the rem or the sievert (1 sievert = 100 rem).

ephemeral. Lasting for a brief period of time; short-lived, transitory.

exposure. A measure of the ionization produced in air by X-ray or gamma + radiation. The special unit of exposure is the roentgen (R).

friable. Readily crumbled; brittle.

gamma ray. High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an atom. Gamma radiation frequently accompanies the emission of alpha or beta particles. Gamma rays are identical to X-rays except for the source of the emission.

half-life, radioactive. The time required for a given amount of a radionuclide to lose half of its activity by radioactive decay. Each radionuclide has a unique half-life.

isotopes. Forms of an element having the same number of protons in their nuclei and differing in the number of neutrons.

minimum detectable concentration (MDC). The smallest amount or concentration of a radioelement that can be distinguished in a sample by a given measurement system in a preselected counting time at a given confidence level.

natural radiation. Radiation arising from cosmic sources and from naturally occurring radionuclides (such as radon) present in the human environment.

outfall. The place where a storm sewer or effluent line discharges to the environment.

part per billion (ppb). Concentration unit approximately equivalent to micrograms per liter.

part per million (ppm). Concentration unit approximately equivalent to milligrams per liter.

pathway. Potential route for exposure to radioactive or hazardous materials.

person-rem. The traditional unit of collective dose to a population group. For example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem.

quality factor. The factor by which the absorbed dose (in rad or gray) is multiplied to obtain the dose equivalent (in rem or sievert). The dose equivalent is a unit that expresses on a common scale for all ionizing radiation the biological damage to exposed persons. It is used because some types of radiation, such as alpha particles, are more biologically damaging than others.

rad. A traditional unit of absorbed dose. The International System of Units (SI) unit of absorbed dose is the gray (1 gray = 100 rads).

radioactivity. The spontaneous emission of radiation, generally alpha or beta particles, often accompanied by gamma rays, from the unstable nucleus of an atom.

radionuclide. An atom having an unstable ratio of neutrons to protons so that it will tend toward stability by undergoing radioactive decay. A radioactive nuclide.

rem. The traditional unit of dose equivalent. Dose equivalent is frequently reported in units of millirem (mrem), which is one-thousandth of a rem. The International System of Units (SI) unit of dose equivalent is the sievert (1 sievert = 100 rem).

roentgen (R). The traditional unit of exposure to X-ray or gamma radiation based on the ionization in air caused by the radiation. One roentgen is equal to 2.58 x 10^{-4} coulombs per kilogram of air. A common expression of radiation exposure is the milliRoentgen (1R = 1000 mR).

sievert (Sv). International System of Units (SI) unit for radiation dose (1 sievert = 100 rem).

thermoluminescent dosimeter (TLD). A device used to measure external sources (i.e., outside the body) of penetrating radiation such as X-rays or gamma rays.

uncontrolled area. Any area to which access is not controlled for the purpose of protecting individuals from exposure to radiation and radioactive materials. The area beyond the boundary of the RFP is an uncontrolled area.

worldwide fallout. Radioactive debris from atmospheric weapons testing that is either airborne and cycling around the earth or has been deposited on the earth's surface.

Appendix A

PERSPECTIVE ON RADIATION

INTRODUCTION

Activities at the RFP involve handling radioactive materials and operating radiation-producing equipment. Environmental monitoring programs include monitoring for potential exposures to the public from RFP-related radiation sources. This section provides the basic concepts of radiation to assist in the understanding and interpretation of monitoring information and radiation dose assessment.

Further discussion on sources of ionizing radiation can be found in Report No. 93 of the National Council on Radiation Protection and Measurements, *Ionizing Radiation Exposure of the Population of the United States* (NA87a), from which much of the information in this section was derived.

IONIZING RADIATION

Many kinds of radiation exist in our environment. Visible light and heat radiating from a warm object are examples. Radiation from radioactive materials and radiation-producing equipment is called ionizing radiation. Ionizing radiation has sufficient energy to separate electrons from atoms of material. This separation is called ionization. When ionizing radiation is absorbed in living tissues, it can cause damage from the ionization process. Consequently, protective measures may be required to minimize the amount of ionizing radiation to which a person might be exposed.

Types of Radiation

Common types of ionizing radiation include alpha, beta, gamma, X-ray, and neutron radiation. While all types can produce ionization, they have other differing properties including their ability to penetrate or pass through materials. Alpha radiation penetrates poorly; a piece of paper or outer skin tissue can stop it. Beta radiation has low to moderate penetrating ability. Gamma, X-ray, and neutron radiation usually have much greater penetrating ability. Radiation produced by medical X-ray machines, for example, is able to pass through a human body.

Production of Radiation

Ionizing radiation is produced by radioactive materials and radiation-producing equipment. Radiation-producing equipment includes X-ray machines and linear accelerators. Electrical power must be applied to this equipment to produce radiation. In contrast, radioactive materials will continue to emit ionizing radiation until they have undergone radioactive decay to nonradioactive, stable states. The time required for a material to reach this stable state depends on a material's radioactive half-life. Half-life is the amount of time required for one-half of the atoms of a radioactive material to experience radioactive decay. Half-life is unique and unchanging for each specific radionuclide. Half-lives for different radionuclides may vary from seconds to billions of years.

Radiation Dose

The biological effect of ionizing radiation is called radiation dose. The radiation can be from a penetrating radiation source located outside of the body (external radiation) or from radioactive materials taken into the body (internal radiation). In the United States, radiation dose is measured in the unit called the rem or millirem (1 rem = 1,000 millirem). The comparable International Standard (SI) unit of radiation dose is the sievert (1 Sv = 100 rem). A rem is a unit of biological dose that expresses biological damage on a common scale. The EDE is a means of calculating radiation dose. EDE takes into account the total health risk estimated for cancer mortality and serious genetic effects from radiation exposure regardless of which body tissues receive the dose or the sources or types of ionizing radiation producing the dose.

SOURCES OF RADIATION

All living things are exposed to naturally occurring ionizing radiation. However, since the discovery of radiation and radioactive materials at the beginning of this century, we might significantly increase our amount of radiation exposure through use of artificially produced or enhanced sources of radiation.

Natural Sources

Naturally occurring sources are the greatest contributor to radiation exposures for the people living in the

United States. Sources of natural background radiation include cosmic radiation from space and secondary radioactive materials (cosmogenic nuclides) created when cosmic radiation enters our atmosphere. Another source is naturally occurring radioactive materials originating from the earth's crust, referred to as primordial nuclides. These materials may contribute to radiation exposure when located outside the body or when taken into the body through inhalation or ingestion. Radon, for example, a radioactive gas derived from uranium, is an important contributor to internal radiation exposure as a result of inhalation inside buildings.

Different living situations can result in more or less exposure to naturally occurring ionizing radiation. Cosmic radiation exposure can increase as altitude increases because less atmosphere exists to shield against the radiation. Some geographical areas have higher concentrations of primordial nuclides such as uranium and thorium. Because the Denver area is located at a relatively high altitude and also has higher concentrations of uranium and thorium in rocks and soil, naturally occurring radiation levels are higher than those in many other regions in the country.

The annual, naturally occurring EDE to a typical resident of the Denver metropolitan area is given in Section 6. The total for this area, based on current published reports, is about 350 mrem/yr. This estimate may increase as the Denver regional difference in indoor radon concentration is determined. By comparison, the estimated total average EDE for a member of the United States population from natural sources is about 300 mrem/yr.

Medical Sources

Ionizing radiation is used in medicine for diagnosis and treatment of many medical conditions. This radiation can be produced by equipment such as X-ray machines or linear accelerators, or it can originate from radioactive materials incorporated into pharmaceuticals. Medical diagnosis and treatment account for the largest radiation doses to the United States public from artificially produced sources of radiation. The average EDE to a member of the United States population from medical sources is about 50 mrem/yr. However, individual doses from this source vary widely, with some people receiving little or none and others receiving much more than the average in any particular year.

Consumer Products Sources

Some consumer products, including tobacco, smoke detectors, and television sets, have ionizing radiation associated with them. Consumer products are the second largest contributor to radiation dose to the United States population from artificially produced or enhanced sources. The radiation may or may not be intentional and necessary for the functioning of the product. Ionization smoke detectors and X-ray baggage inspection systems at airports require ionizing radiation to perform their functions. Tobacco products, fuels such as coal, and television receivers have radiation associated with them even though it is not necessary for their use.

Other Sources

Naturally occurring, medical, and consumer product sources contribute over 99 percent of the average radiation dose that a person living in the United States receives each year (Figure A-1). Other sources include occupational exposures, residual fallout from past atmospheric weapons testing, the nuclear fuel cycle, and miscellaneous sources. Combined, these other sources contribute less than 1 percent of the average radiation dose to a person living in the United States.

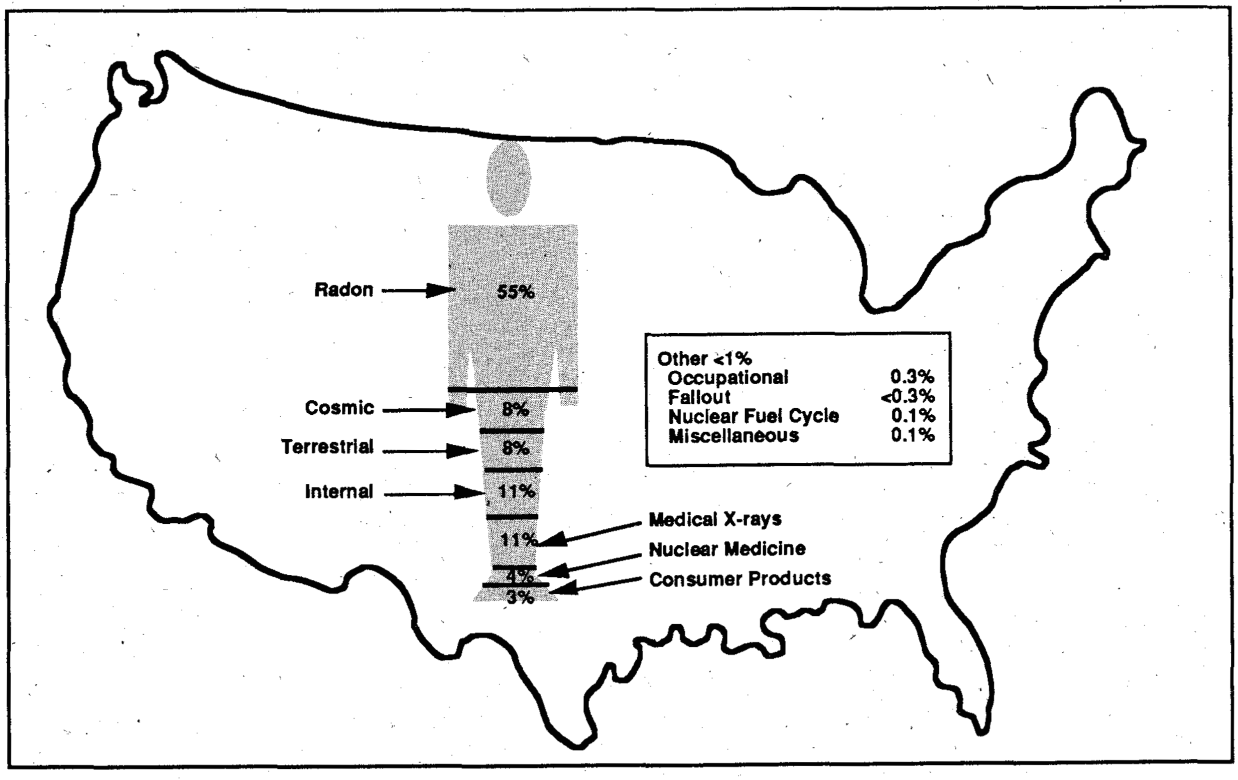


Figure A-1. Contribution of Various Sources to the Total Average Radiation Dose to the United States Population

Appendix B

APPLICABLE GUIDES AND STANDARDS

APPLICABLE GUIDES AND STANDARDS

RFP environmental monitoring programs evaluate plant compliance with applicable guides, limits, and standards. Guide values and standards for radionuclides in ambient air and waterborne effluents have been adopted by the Department of Energy (DOE), the Colorado Department of Health (CDH), the Colorado Water Quality Control Commission (CWQCC) (water only), and by the Environmental Protection Agency (EPA) (for the air pathway only) (CDH78, EPA85). Many of these guides are based on recommendations published by the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP).

AIR STANDARDS

Effluent Air

Air effluent limits are established under the CAA NESHAPs. Limits for radiation dose from radioactivity emissions are promulgated by EPA and are listed in Table B-1 (see "Air Pathway Only"). Nonradioactive (but otherwise hazardous) materials emissions are regulated by the State of Colorado under Colorado Air Quality Control Regulation #8. Regarding hazardous air pollutants at RFP, this regulation sets a limit for beryllium of 10 grams per stationary source in a 24-hour period.

Ambient Air

Ambient air data for nonradioactive particulates have been collected historically at RFP for comparison to criteria pollutants listed under the EPA NAAQS (EPA81) established by the CAA (US83) (Table B-2). Instrumentation and methodology follow requirements established by the EPA in the *Quality Assurance Handbook for Air Pollution Measurement Systems* (EPA76b).

Ambient air data for radioactive particulates are compared with Derived Concentration Guides (DCGs) given in Table B-3. A further explanation of DCG is given in the Radiological Dose Standards section.

WATER STANDARDS

The DCGs for surface water effluents are given in Table B-3. A further explanation of DCG standards is given in the Radiological Dose Standards section.

Table B-1
DOE Radiation Protection Standards for the Public

ICRP-RECOMMENDED STANDARDS FOR ALL PATHWAYS:

Temporary Increase	500 mrem/year Effective Dose Equivalent (with prior approval of DOE EH-2)
Normal Operations	100 mrem/year Effective Dose Equivalent

EPA CLEAN AIR ACT NESHAP STANDARDS FOR THE AIR PATHWAY ONLY:

10 mrem/year Effective Dose Equivalent

Table B-2
National Ambient Air Quality Standards (NAAQS) for Particulates

	NAAQS Averaging Time	Concentration
PM-10:	Annual Arithmetic Mean	50 $\mu g/m^3$
	24-hr Average[a]	150 $\mu g/m^3$
TSP[b]:	Annual Geometric Mean	75 $\mu g/m^3$
	24-hr Average	260 $\mu g/m^3$

a. Not to be exceeded more than once per year.
b. TSP no longer used for determining compliance with NAAQS. Sampling and reporting continues for comparison purposes and general interest.

Table B-3
DOE Derived Concentration Guides for Radionuclides of Interest at RFP[a]

Air Inhalation:	Radionuclide	DCG (μCi/ml)
	Plutonium-239, -240	20×10^{-15}
Water Ingestion:	**Radionuclide**	**DCG (μCi/ml)**
	Plutonium-239, -240	30×10^{-9}
	Americium-241	30×10^{-9}
	Uranium-233, -234	500×10^{-9}
	Uranium-238	600×10^{-9}
	Hydrogen-3 (Tritium)	$2{,}000{,}000 \times 10^{-9}$

a. Based on most restrictive assumptions for lung clearance class and gastrointestinal uptake fraction.

Surface Water Effluent

National Pollutant Discharge Elimination System (NPDES). The NPDES permit sets limits for nonradioactive pollutants; typical examples are listed below (Table B-4). The RFP NPDES permit, reissued to DOE in 1984 and administratively extended in 1989 by the EPA, establishes effluent limitations for seven discharge points from which Ponds A-3, A-4, B-5, and C-2 discharge into drainages leading off of RFP property.

Colorado Water Quality Control Commission Water Quality Standards. Resegmentation of Big Dry Creek and revised use classifications and water quality standards for Woman Creek and Walnut Creek tributaries to Standley Lake and Great Western Reservoir became effective on March 30, 1990. This action by the CWQCC established stream standards with temporary modifications for Segment 5 of Big Dry Creek (tributaries from source to ponds A-4, B-5, and C-2) and final stream standards for Segment 4 of Big Dry Creek (from pond outlets to Standley Lake and Great Western Reservoir). Stream standards were adopted for organic and inorganic chemicals, metals, radionuclides, and certain physical and biological parameters (Tables B-5 through B-7).

Table B-4

NPDES Discharge Limitations for the RFP[a]

Parameter	Monthly Average	Weekly Average	Daily Maximum
Effluent Water Samples (Nonradioactive)			
pH		6.0-9.0 SU	
Nitrates as N	10 mg/l	20 mg/l	NA
Total Phosphorus	8 mg/l	NA	12 mg/l
Biochemical Oxygen Demand, 5-Day	10 mg/l	NA	25 mg/l
Suspended Solids	30 mg/l	45 mg/l	NA
Total Chromium	0.05 mg/l	NA	0.1 mg/l
Residual Chlorine	NA	NA	0.5 mg/l
Oil and Grease	NA	NA	Visual
Fecal Coliform - No./100 ml	200	400	NA

a. These limitations are presented as indicators of the types of parameters and associated concentration limits required by the NPDES permit. Details of these requirements specific to each discharge location are given in the referenced document (EPA84). The daily and monthly limitations indicated cannot be correlated with the annual water quality data summarized in the text.

A goal qualifier was applied by the CWQCC to Segment 5, indicating that at the time standards were established, the waters were not suitable but are intended to become fully suitable for the classified use. The temporary modifications of ambient quality for Segment 5 expire February 1, 1993. The CWQCC has scheduled a Rulemaking Hearing for October 1992, to consider an extension of the temporary modifications.

Drinking Water

In 1976, the EPA promulgated regulations for radionuclides in drinking water (EPA76a). These regulations were effective on June 24, 1977, along with primary drinking water regulations for microbiological, chemical, and physical contaminants. The intent of the Safe Drinking Water Act was to ensure that each state has primary responsibility for maintaining drinking water quality. To comply with these requirments, the CDH modified existing state drinking water standards to include radionuclides (CDH77, CDH81). Two of the community drinking water standards are of interest in this report. The state standard for gross alpha activity (including radium-226 but excluding radon and uranium) in community water systems is a maximum of 15 pCi/l or 15 x 10^{-9} μCi/ml (5.6 x 10^{-1} Bq/l). Americium and plutonium, which are alpha-emitting radionuclides, are included in this limit. The limit for tritium in drinking water is 20,000 pCi/l or 20,000 x 10^{-9} μCi/ml (740 Bq/l).

The EPA proposed additional National Primary Water Standards for radionuclides in 1991. These standards are not yet formalized.

SOIL STANDARDS

The standard for plutonium adopted by CDH in 1973 is 2.0 disintegrations per minute per gram (dpm/g) (0.9 pCi/g) for a soil density of 1 gram per square centimeter (g/cm^2) for soils sampled to a depth of 0.64 cm (1/4 in.) (CDH73).

Table B-5
Colorado Water Quality Control Commission (CWQCC) Water Quality Stream Standards Effective Date - March 30, 1990

Goal Qualifiers, Segment 5 of Big Dry Creek

Chemical Classification	Parameter	CWCC Standards (mg/l)
Physical and Biological	Dissolved Oxygen	5.0
	pH	6.5 - 9.0
	Fecal Coliforms	2000/100 ml
	Ammonia	
	(Acute)	TVS 0.10
	(Chronic)	0.06
Inorganic	Chlorine	0.019 (ac)
	Cyanide	0.011 (ch)
	Sulfate as Hydrogen Sulfide	.002
	Nitrite	1.0
	Nitrate	10.0
	Chloride	250.0
	Sulfate	250.0
	Boron	.75
Metals	Arsenic	.05
	Cadmium	TVS[a]
	Chromium III	.05
	Chromium VI	TVS
	Copper	TVS
	Iron (Dissolved)	.3
	Iron (Total Recovery)	1.0
	Lead	TVS
	Manganese (Dissolved)	.05
	Manganese (Total Recovery)	1.00
	Mercury	.00001
	Nickel	TVS
	Selenium	.01
	Silver	TVS
	Zinc	TVS

a. Table Value Standard

Table B-6

CWQCC Water Quality Stream Standards - Organic Chemical Standards[a] (µg/l)

Parameter	CAS Number	Chronic Standard	Gas Chromatography (GC) Detection Levels
Acrylonitrile	107-1	3-10.058	10*
Aldrin	309-00-2	0.000074	0.05
Atrazine		3.0	1
Benzidine	92-87-5	0.00012	10*
Chlordane	57-74-9	0.00046	0.5
Chloroform	67-66-3	0.19	0.2/5.0
Chloroethyl Ether BIS	111-44-4	0.0000037	10*
DDT	50-29-3	0.000024	0.1
Dichlorobenzidine	91-94-1	0.01	10*
Dieldrin	60-57-1	0.000071	0.1
Dioxin (2, 3, 7, 8OTCDD)	1746-01-6	0.000000013	
Halomethanes		0.19	
Heptachlor	76-44-8	0.00028	0.5
Hexachloroethane	67-72-1	1.9	1
Hexachlorobenzene	118-74-1	0.00072	1
Hexachlorobutadiene	87-68-3	0.45	0.2/1.0
Hexachlorocyclohexane, Alpha	319-84-6	0.0032	0.05
Hexachlorocyclohexane, Beta	319-85-7	0.0163	0.05
Hexachlorocyclohexane, Gamma (Lindane)	58-89-9	0.0186	0.05
Hexachlorocyclohexane, Technical	608-73-1	0.0123	
Nitrosodibutylamine N		0.0064	5
Nitrosodiethylamine N		0.0008	5
Nitrosodiphenylamine N	86-30-6	4.9	10
Nitrosopyrrolidine N		0.016	10*
PCBs	1336-36-3	0.000079	
Simazine		4	0.18
Tetrachloroethane 1, 1, 2, 2	79-34-5	0.17	0.2/5.0
Tetrachloroethane	79-34-5	0.8	0.2
Trichloroethane 1, 1, 2	79-00-5	0.6	0.2/5.0
Trichlorophenol 2, 4, 6	88-06-2	1.2	1

a. In the absence of specific, numeric standards for non-naturally occurring organics, the narrative standard "no toxics in toxic amounts" (Section 3.2.22 [1] [d]) shall be inerpreted as zero with enforcement based on the practical quantification levels (PQLs) for those compounds as defined by the Water Quality Control Division or the U.S. Environmental Protection Agency.

* Gas Chromatography/Mass Spectrometry Method.

Table B-7

CWQCC Water Quality Stream Standards - Radionuclides[a]

The radionuclides listed below shall be maintained at the lowest practical level; in no case shall they be increased by any cause attributable to municipal, industrial, or agricultural practices to exceed the site-specific numeric standards.

A. Ambient based site-specific standards:

	Segment 2 Standley Lake	Segment 3 Great Western Reservoir	Segment 4 Segment 5 Woman Creek	Segment 4 Segment 5 Walnut Creek
Gross Alpha	6	5	7	11
Gross Beta	9	12	5	19
Plutonium	.03	.03	.05	.05
Americium	.03	.03	.05	.05
Tritium	500	500	500	500
Uranium	3	4	5	10

B. Other site-specific standards applicable to segments 2, 3, 4, and 5:

Curium-244	60
Neptunium-237	30

a. Statewide standards also apply for radionuclides not listed above. Values listed are in pCi/l.

The EPA has not established a standard for plutonium concentration but has proposed a screening level of 44.4 dpm/g (19.98 pCi/g) for a soil density of 1 g/cm^2 for soils sampled to a depth of 1 centimeter (0.394 inches) (EPA77).

RADIOLOGICAL DOSE STANDARDS

On February 8, 1990, DOE adopted DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, a radiation protection standard for DOE environmental activities (DOE90a). This standard incorporates guidance from the ICRP, as well as from the EPA Clean Air Act NESHAP standards (as implemented in 40 CFR 61, Subpart H) (US83, EPA85). Included in DOE Order 5400.5 is a revision of the dose limits for members of the public. Tables of radiation dose conversion factors currently used for calculating dose from intakes of radioactive materials were issued in July 1988 (DOE88a, DOE88b). The dose factors are based on the ICRP Publications 30 and 48 methodology and biological models for radiation dosimetry (IN79, IN86). The DOE Order 5400.5 and the dose conversion factor tables are used for assessment of any potential RFP contribution to public radiation dose. On December 15, 1989, EPA published revised CAA NESHAP standards for DOE facilities (EPA89b). DOE radiation standards for protection of the public are given in this Appendix and include the December 15, 1989, EPA CAA air pathway standards.

DOE Derived Concentration Guides

Secondary radioactivity concentration guides can be calculated from the primary radiation dose standards and used as comparison values for measured radioactivity concentrations. DOE provides tables of these DCGs in DOE Order 5400.5. DCGs are the concentrations that would result in an EDE of 100 mrem from 1 year's chronic exposure or intake. In calculating air inhalation DCGs, DOE assumes that the exposed individual inhales 8,400 cubic meters of air at the calculated DCG during the year. Ingestion DCGs assume a water intake of 730 liters at the calculated DCG for the year. Table B-3 lists the most restrictive air and water DCGs for the principal radionuclides of interest at the RFP.

Plutonium Concentrations. Plutonium concentrations at RFP represent the alpha radioactivity from plutonium-239 and -240. These constitute over 97 percent of the alpha radioactivity in plutonium used at the plant.

Uranium Concentrations. Uranium concentrations are the cumulative alpha activity from uranium-233, -234, and -238. Components containing fully enriched uranium are handled at the RFP. Depleted uranium metal can be fabricated and is also handled as a process waste material. Uranium-235 is the major isotope by weight (93 percent) in fully enriched uranium; however, uranium-234 accounts for approximately 97 percent of the alpha activity of fully enriched uranium. In depleted uranium, the combined alpha activity from uranium-234 and -238 accounts for approximately 99 percent of the total alpha activity. Uranium DCGs used in this report for air and water are those for uranium -233, -234, and -238, which are the most restrictive.

Environmental uranium concentrations can be measured by various laboratory techniques. Nonradiological techniques yield concentration units of mass per unit volume such as milligram per cubic meter and milligram per liter. Uranium concentrations given in this report were derived by measuring radioactivity from alpha-emitting uranium isotopes and are expressed in terms of activity units per unit volume. RFP data include measurements of depleted uranium, fully enriched uranium, and natural uranium.

Conversion factors for specific types of uranium can be used to compare the data in this report to data from other facilities and agencies that are given in units of mass per unit volume; however, the resulting approximations will not have the same assurance of accuracy as that of the original measured values. Uranium in effluent air from plant buildings is primarily depleted uranium. The conversion factor for these data is 2.6×10^6 g/Ci. Natural uranium is the predominant species found in water. The conversion factor for water data is 1.5×10^6 g/Ci.

Appendix C

WIND STABILITY CLASSES

Table C-1

Wind Frequency Distribution by Percent in 1991, Stability Class A[a,b,c]

Wind Speed Classes (Knots)

Wind	<3.0	3.0-<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	>21.0	Class[d]	Total[e]
N	2.3	1.2	0	0	0	0	3.49	0.03
NNE	5.8	1.2	0	0	0	0	6.98	0.07
NE	3.5	4.7	0	0	0	0	8.14	0.08
ENE	12.8	4.7	0	0	0	0	17.44	0.17
E	10.5	10.5	0	0	0	0	20.93	0.21
ESE	12.8	3.5	0	0	0	0	16.28	0.16
SE	4.7	4.7	0	0	0	0	9.3	0.09
SSE	1.2	1.2	0	0	0	0	2.33	0.02
S	4.7	1.2	0	0	0	0	5.81	0.06
SSW	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0
W	1.2	0	0	0	0	0	1.16	0.01
WNW	3.5	2.3	0	0	0	0	5.81	0.06
NW	1.2	0	0	0	0	0	1.16	0.01
NN	1.2	0	0	0	0	0	1.16	0.01
All	65.1	34.9	0	0	0	0	100	1

a. Measurements taken at the 10-meter level from the 61-meter meteorological monitoring tower.
b. Total number of invalid and valid observations in this stability class were 0 and 114, respectively.
c. Calms are distributed as per NCDC Star Deck procedures.
d. Total percent for this stability class.
e. Total percent relative to all stability classes.

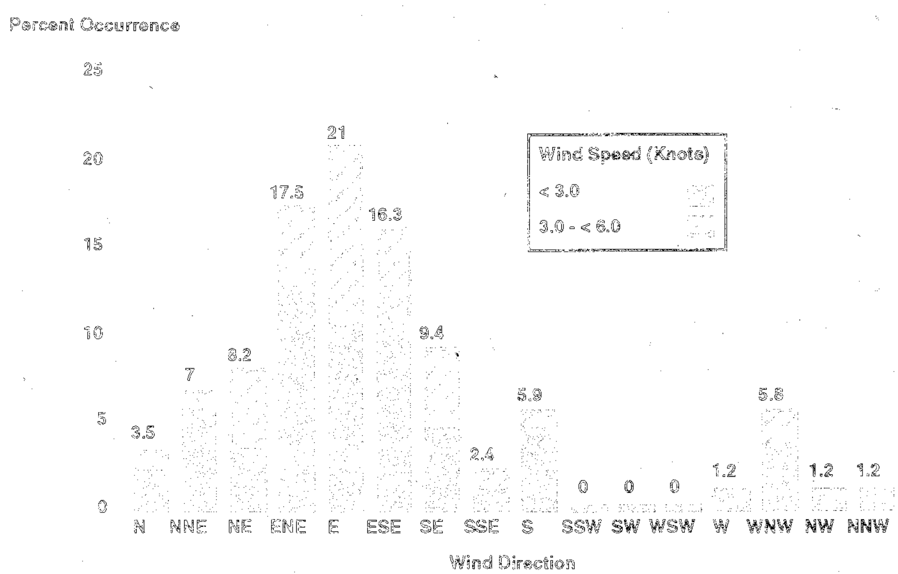


Figure C-1. Stability Class - A

Table C-2

Wind Frequency Distribution by Percent in 1991, Stability Class B[a,b,c]

Wind Speed Classes (Knots)

Wind	<3.0	3.0-<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	>21.0	Class[d]	Total[e]
N	1.8	0.9	0	0	0	0	2.63	0.03
NNE	5.3	6.1	0	0	0	0	11.4	0.15
NE	6.1	10.5	0	0	0	0	16.67	0.22
ENE	3.5	9.6	0	0	0	0	13.16	0.17
E	5.3	14	0	0	0	0	19.3	0.25
ESE	7.9	7	0	0	0	0	14.91	0.2
SE	1.8	6.1	0	0	0	0	7.89	0.1
SSE	0	3.5	0	0	0	0	3.51	0.05
S	0	2.6	0	0	0	0	2.63	0.03
SSW	0	0.9	0	0	0	0	0.88	0.01
SW	0.9	0	0	0	0	0	0.88	0.01
WSW	0	0.9	0	0	0	0	0.88	0.01
W	1.8	0	0	0	0	0	1.75	0.02
WNW	0	0	0	0	0	0	0	0
NW	0.9	0.9	0	0	0	0	1.75	0.02
NNW	0.9	0.9	0	0	0	0	1.75	0.02
All	36	64	0	0	0	0	100	1.32

a. Measurements taken at the 10-meter level from the 61-meter meteorological monitoring tower.
b. Total number of invalid and valid observations in this stability class were 0 and 86, respectively.
c Calms are distributed as per NCDC Star Deck procedures.
d. Total percent for this stability class.
e. Total percent relative to all stability classes.

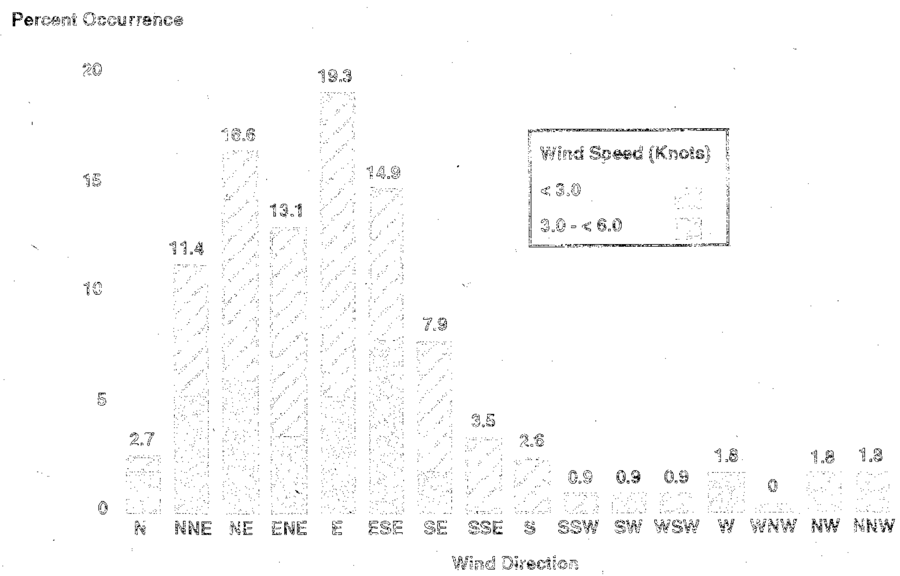


Figure C-2. Stability Class - B

Table C-3

Wind Frequency Distribution by Percent in 1991, Stability Class C[a,b,c,]

Wind Speed Classes (Knots)

Wind	<3.0	3.0-<6.0	6.0-<10.0	01.0-<16.0	16.0-<21.0	>21.0	Class[d]	Total[e]
N	1.1	3.4	0.3	0	0	0	4.89	0.2
NNE	0.9	9.8	0.3	0	0	0	10.92	0.44
NE	1.4	12.9	0	0	0	0	14.37	0.58
ENE	1.4	9.5	0.3	0	0	0	11.21	0.45
E	1.4	14.7	0	0	0	0	16.09	0.65
ESE	0.6	18.4	0	0	0	0	18.97	0.76
SE	0.9	9.5	0	0	0	0	10.34	0.42
SSE	0.3	3.2	0	0	0	0	3.45	0.14
S	0.6	1.1	0	0	0	0	1.72	0.07
SSW	0.3	0	0	0	0	0	0.29	0.01
SW	0.6	1.7	0	0	0	0	2.3	0.09
WSW	0.6	0.3	0	0	0	0	0.86	0.03
W	0.3	0	0	0	0	0	0.29	0.01
WNW	0.9	0.3	0	0	0	0	1.15	0.05
NW	0.6	0.6	0	0	0	0	1.15	0.05
NNW	0.6	1.4	0	0	0	0	2.01	0.08
All	12.4	86.8	0.9	0	0	0	100	4.03

a. Measurements taken at the 10-meter level from the 61-meter meteorological monitoring tower.
b. Total number of invalid and valid observations in this stability class were 0 and 348, respectively.
c. Calms are distributed as per NCDC Star Deck procedures.
d. Total percent for this stability class.
e. Total percent relative to all stability classes.

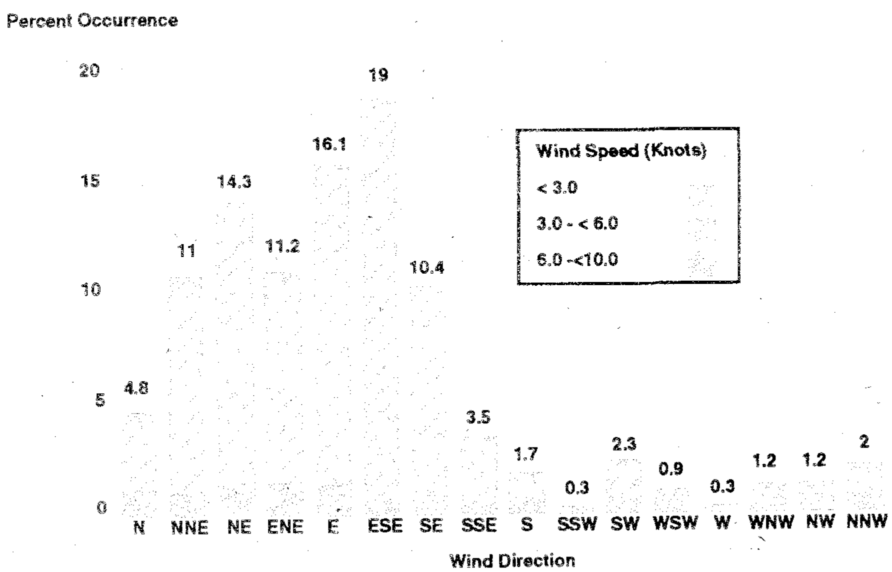


Figure C-3. Stability Class - C

Table C-4

Wind Frequency Distribution by Percent in 1991, Stability Class D[a,b,c]

Wind Speed Classes (Knots)

Wind	<3.0	3.0 -<6.0	6.0–<10.0	10.0–<16.0	16.0–<21.0	>21.0	Class[d]	Total[e]
N	0.4	2.2	3.1	2.4	0.2	0	8.36	3.94
NNE	0.4	2.8	3	1.7	0.1	0	7.99	3.77
NE	0.3	2.4	1.7	0.3	0	0	4.75	2.24
ENE	0.4	2.1	0.9	0.2	0	0	3.59	1.7
E	0.3	2	1.1	0.1	0	0	3.4	1.6
ESE	0.2	2.8	1.6	0.1	0	0	4.68	2.21
SE	0.2	2.7	2.6	0.4	0.1	0	6.07	2.87
SSE	0.3	2.2	2.8	1	0.2	0.2	6.59	3.11
S	0.2	1.6	1.3	0.9	0.2	0	4.21	1.98
SSW	0.3	0.7	0.7	1	0.1	0	2.75	1.3
SW	0.3	0.9	0.7	1.2	0.1	0	3.2	1.51
WSW	0.3	0.4	0.7	2.6	0.6	0.2	4.94	2.33
W	0.5	0.4	0.7	4.3	1.7	1.7	9.29	4.38
WNW	0.4	0.8	1	7.9	3.5	2.8	16.38	7.73
NW	0.4	0.8	1.3	3.9	1.2	0.3	7.91	3.73
NNW	0.3	1.7	2.2	1.6	0.1	0	5.9	2.78
All	5.2	26.3	25.4	29.5	8.2	5.4	100	47.18

a. Measurements taken at the 10-meter level from the 61-meter meteorological monitoring tower.
b. Total number of invalid and valid observations in this stability class were 0 and 4,072, respectively.
c. Calms are distributed as per NCDC Star Deck procedures.
d. Total percent for this stability class.
e. Total percent relative to all stability classes.

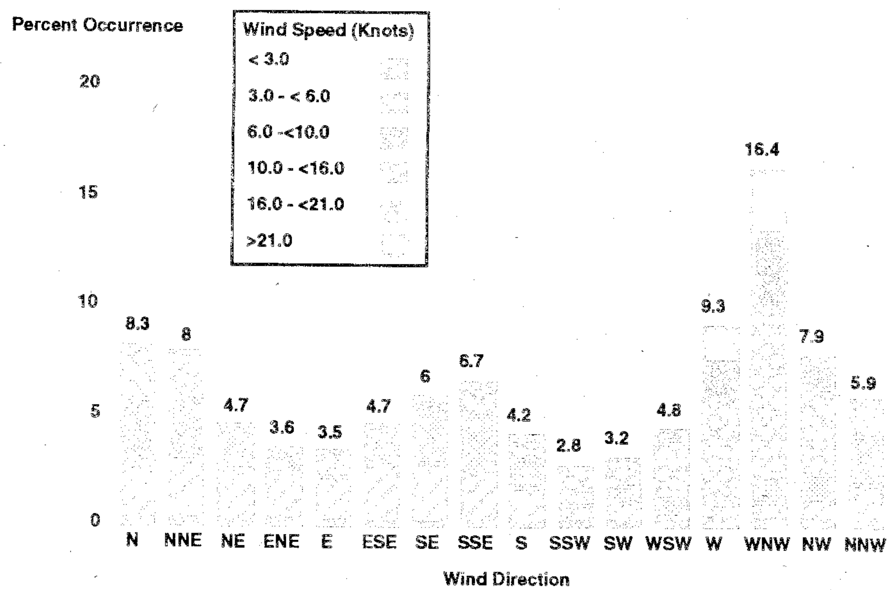


Figure C-4. Stability Class - D

Table C-5

Wind Frequency Distribution by Percent in 1991, Stability Class E[a,b,c]

Wind Speed Classes (Knots)

Wind	≤3.0	3.0-<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	≥21.0	Class[d]	Total[e]
N	0.6	2.4	3.7	0	0	0	6.76	2.37
NNE	0.8	1.6	1.6	0	0	0	3.91	1.37
NE	0.4	1.5	0.9	0	0	0	2.82	0.99
ENE	0.3	1.4	0.3	0	0	0	2.02	0.71
E	0.2	1.3	0.4	0	0	0	1.92	0.67
ESE	0.3	1.2	0.5	0	0	0	2.02	0.71
SE	0.3	1.4	0.7	0	0	0	2.42	0.85
SSE	0.6	1.6	2.7	0	0	0	4.49	1.72
S	0.5	2	3.9	0	0	0	6.43	2.25
SSW	0.6	1.9	4.5	0	0	0	7.06	2.47
SW	0.6	2.3	6.3	0	0	0	9.24	3.24
WSW	0.9	3.5	7.7	0	0	0	12.19	4.27
W	0.6	3.2	4.8	0	0	0	8.61	3.02
WNW	1.1	3.4	5.5	0	0	0	10.01	3.51
NW	0.7	3.3	5.7	0	0	0	9.64	3.38
NNW	0.5	2.9	6.6	0	0	0	10.04	3.52
All	9.2	34.8	56	0	0	0	100	35.04

a. Measurements taken at the 10-meter level from the 61-meter meteorological monitoring tower.
b. Total number of invalid and valid observations in this stability class were 0 and 3,024, respectively.
c. Calms are distributed as per NCDC Star Deck procedures.
d. Total percent for this stability class.
e. Total percent relative to all stability classes.

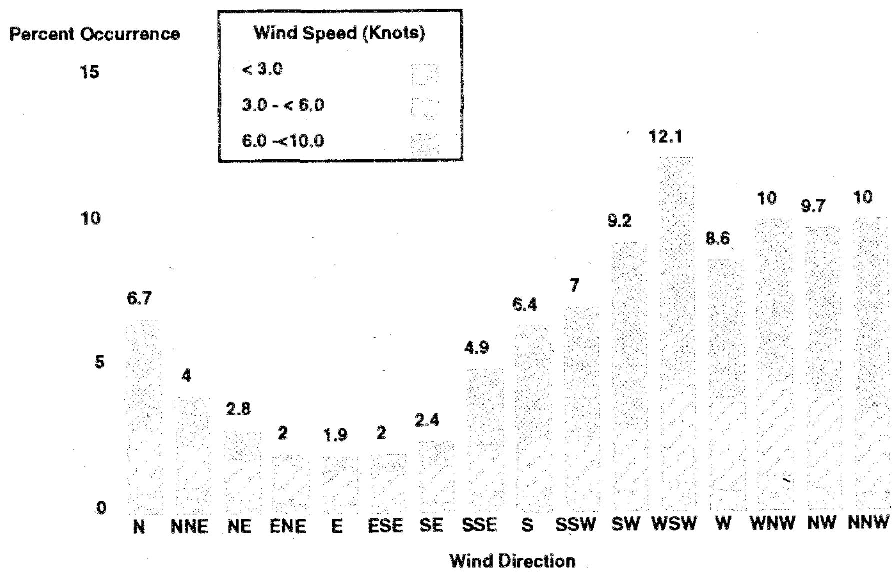


Figure C-5. Stability Class - E

Table C-6

Wind Frequency Distribution by Percent in 1991, Stability Class F[a,b,c]

Wind Speed Classes (Knots)

Wind	≤3.0	3.0 -<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	≥21.0	Class[d]	Total[e]
N	0.1	4	0	0	0	0	4.09	0.47
NNE	0.3	1.2	0	0	0	0	1.54	0.18
NE	0	0.8	0	0	0	0	0.82	0.09
ENE	0	0.6	0	0	0	0	0.61	0.07
E	0.4	1	0	0	0	0	1.43	0.16
ESE	0.1	0.4	0	0	0	0	0.51	0.06
SE	0.1	1.7	0	0	0	0	1.84	0.21
SSE	0.2	4.5	0	0	0	0	4.71	0.54
S	0.1	5.5	0	0	0	0	5.53	0.63
SSW	0.3	8.2	0	0	0	0	8.5	0.97
SW	0.3	12.5	0	0	0	0	12.79	1.46
WSW	0.5	10.5	0	0	0	0	11.05	1.26
W	0.4	14	0	0	0	0	14.43	1.65
WNW	0.3	13.5	0	0	0	0	13.82	1.58
NW	0.3	10.6	0	0	0	0	10.95	1.25
NNW	0.5	6.9	0	0	0	0	7.37	0.84
All	4.1	94.8	0	0	0	0	100	11.43

a. Measurements taken at the 10-meter level from the 61-meter meteorological monitoring tower.
b. Total number of invalid and valid observations in this stability class were 0 and 987, respectively.
c. Calms are distributed as per NCDC Star Deck procedures.
d. Total percent for this stability class.
e. Total percent relative to all stability classes.

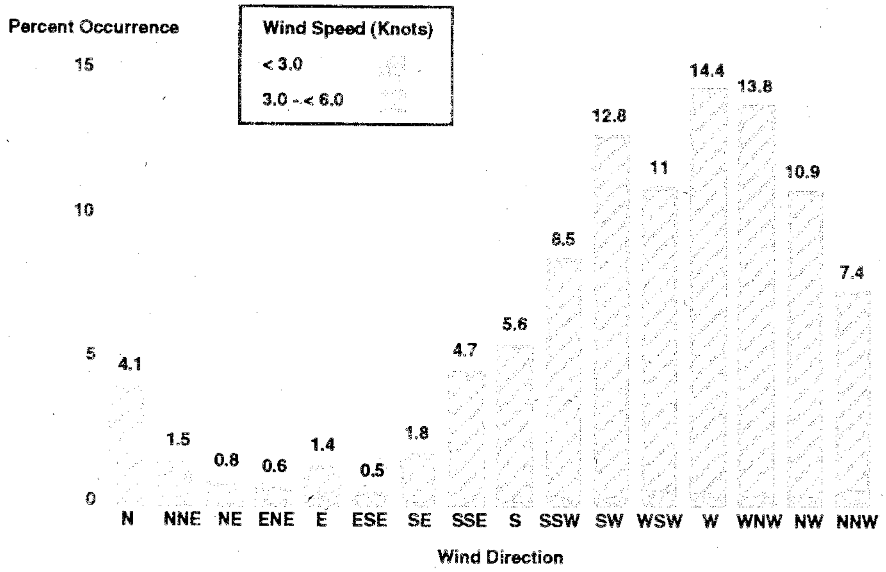


Figure C-6. Stability Class - F

Table C-7

Wind Frequency Distribution by Percent in 1991, Stability Class All [a,b,c,d]

Wind Speed Classes (Knots)

Wind	≤3.0	3.0-<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	≥21.0	Class[e]	Total[f]
N	0.5	2.5	2.8	1.1	0.1	0	7.05	7.05
NNE	0.7	2.5	2	0.8	0	0	5.98	5.98
NE	0.5	2.4	1.1	0.2	0	0	4.2	4.2
ENE	0.5	2.1	0.6	0.1	0	0	3.27	3.27
E	0.5	2.4	0.6	0	0	0	3.55	3.55
ESE	0.5	2.6	1	0	0	0	4.1	4.1
SE	0.3	2.5	1.5	0.2	0.1	0	4.54	4.54
SSE	0.4	2.3	2.3	0.5	0.1	0.1	5.57	5.57
S	0.4	2.2	2	0.4	0.1	0	5.03	5.03
SSW	0.4	1.9	1.9	0.5	0.1	0	4.77	4.77
SW	0.4	2.7	2.5	0.5	0.1	0	6.31	6.31
WSW	0.6	2.7	3.1	1.2	0.3	0.1	7.91	7.91
W	0.5	2.9	2	2	0.8	0.8	9.1	9.1
WNW	0.7	3.1	2.4	3.7	1.6	1.3	12.92	12.92
NW	0.5	2.8	2.6	1.8	0.6	0.2	8.44	8.44
NNW	0.4	2.7	3.3	0.8	0.1	0	7.26	7.26
All	7.8	40.3	31.6	13.9	3.9	2.5	100	100

a. Measurements taken at the 10-meter level from the 61-meter meteorological monitoring tower.
b. Total number of invalid and valid observations were 0 and 8,631 respectively.
c. Calms are distributed as per NCDC Star Deck Procedures.
d. Joint Data recovery rate = 100 percent.
e. Total percent for this stability class.
f. Total percent relative to all stability classes.

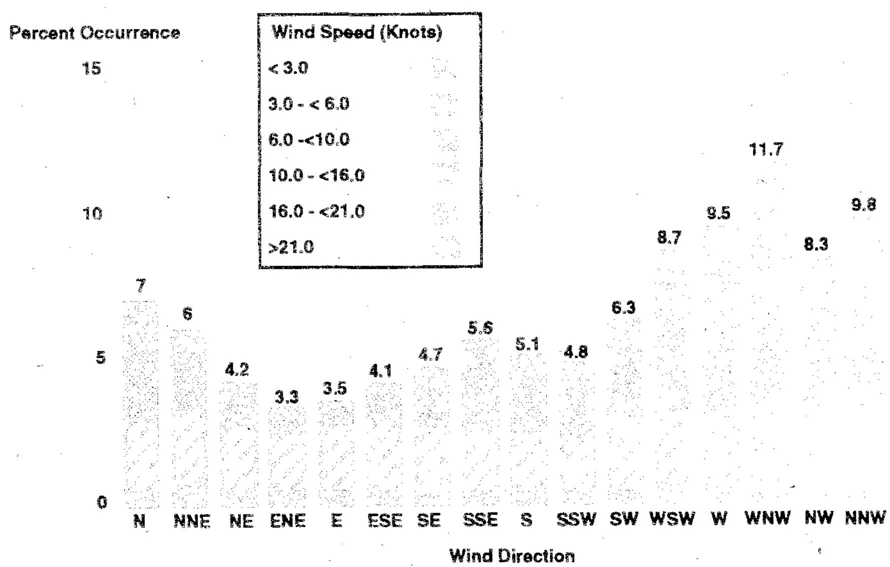
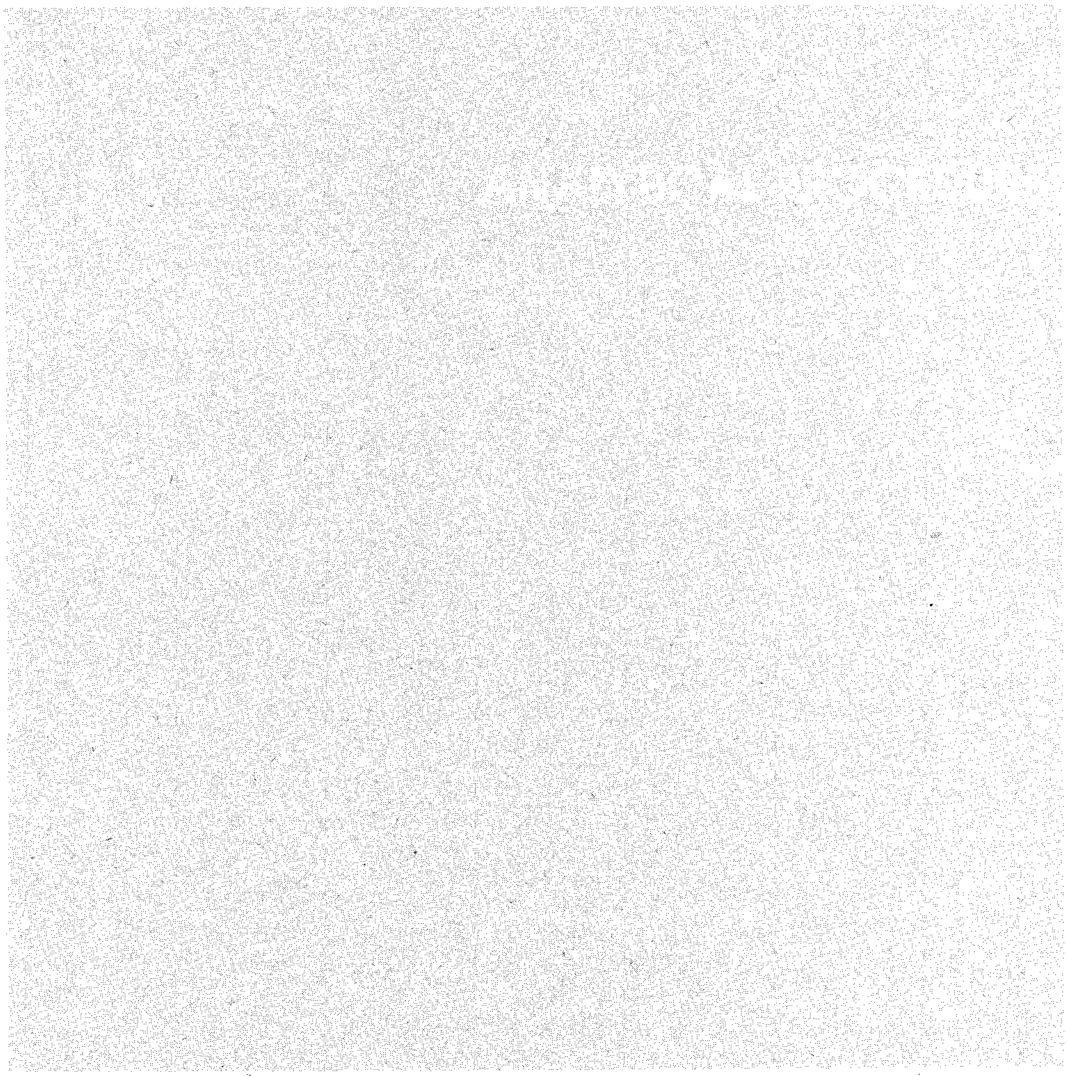


Figure C-7. Stability Class - All



RADIOLOGICAL HEALTH (RH) LABORATORIES

RH Laboratories routinely perform the following analyses on environmental and effluent samples:

1. Total Air Filter Counting (long-lived alpha)
2. Gas Proportional Counting (gross alpha and gross beta)
3. Gamma Spectral Analysis
4. Alpha Spectral Analysis (Plutonium-239, -238; Americium-241; Uranium-238, -233, -234)
5. Beta Liquid Scintillation (Tritium)
6. N,N-Dimethyl-p-phenylenediamine (DPD) (Chlorine)
7. Atomic Absorption (Beryllium)
8. Millipore Filtration Method (Fecal and Total Coliform)

Procedures for these analyses are described in the *Radiological Health Procedures and Practices Manual* (WI82). The procedures for bacteria and chlorine analyses were developed following EPA guidelines. Soil procedures were developed following specifications set forth in *Measurements of Radionuclides in the Environment, Sampling and Analysis of Plutonium in Soil*, Nuclear Regulatory Commission (NRC) Regulatory Guide 4.5. All new procedures and changes to existing procedures must be thoroughly tested, documented, and approved in writing by the manager of RH Laboratories before being implemented. Environmental Management (EM) is notified of any major changes that could affect analytical results. All procedures are reviewed annually (or at any time an analytical problem is suspected) for consistency with state-of-the-art techniques. Copies of all procedures are kept on file in the office of the manager of RH Laboratories.

Analytical Procedures

Samples received for air filter screening are counted at approximately 24 hours and then 48 hours after collection. Samples exceeding specified limits are recounted. If the total long-lived alpha concentration for a screened filter exceeds specified action limits, the filter is directed to individual specific isotope analysis and/or follow-up investigation to determine the cause and any needed corrective action.

All water samples, except those scheduled for tritium analysis, are poured into 1-liter Marinelli containers and sealed before delivery to the gamma counting area. Routine water samples are counted for approximately 12 hours. Samples requiring a lower detection limit are counted from 16 to 72 hours.

Soil samples scheduled for gamma spectral analysis are dried, sieved through a 10-mesh sieve, weighed, and the fine portion is ball-milled. The fine portion is then placed in a 500-milliliter Marinelli container and counted for at least 16 hours.

All samples scheduled for alpha spectral analysis are analyzed in a similar manner regardless of matrix. Before dissolution, a known quantity of nonindigenous radioactive tracer is added to each sample. The tracer is used to determine the chemical recovery for the analysis. Tracers used include plutonium-236, plutonium-242, uranium-232, uranium-236, americium-243, and curium-244. The type and activity level of the tracer used depends on the type and projected activity level of the sample to be analyzed. All refractory or intractable actinides are dissolved by vigorous acid treatment using both oxidizing and complexing acids. After samples are dissolved, the radioisotopes of concern are separated from each other and from the matrix material by various solvent extraction and ion exchange techniques. The purified radioisotopes are electro-deposited onto stainless steel discs. These discs are alpha counted for 12 hours. If a lower minimum detection limit is required, samples may be counted from 72 to 168 hours, depending on the specific sensitivity requirement. Samples that exhibit a chemical recovery of < 10 percent or > 110 percent are automatically scheduled for reanalysis.

Tritium analyses are routinely performed on specified environmental water samples, as well as on stack effluent samples. Ten milliliters of the samples are combined with 10 milliliters of liquid scintillation fluid.

Effluent samples are counted for 30 minutes; environmental samples are counted for 45 minutes.

GENERAL LABORATORY

The General Laboratory routinely performs the following analyses for environmental monitoring of plant effluent streams, process wastes, and soil residues:

1. Metallic elements including tests for 19 cations by inductively coupled plasma spectroscopic techniques and 17 elements by atomic absorption spectroscopy techniques (including beryllium in airborne effluent sample filters).

2. Oxygen demand tests on water including total organic carbon, dissolved oxygen, chemical oxygen demand, carbonaceous biological oxygen demand, and biological oxygen demand (5-day incubation).

3. Nutrient tests including free ammonia, ortho and total phosphate phosphorus, nitrite, and nitrate anions.

4. Physical tests, including pH, conductivity, color, total dissolved solids, suspended solids, total solids, nonvolatile suspended solids, turbidity, and specific gravity.

5. Soap residues (as alkyl sulfonate).

6. Oil and grease residues, by extraction and infrared or gravimetric detection, and by visual observation.

7. Specific chemical property or element including total hardness (as calcium carbonate), alkalinity (as hydroxide, bicarbonate, or carbonate), chloride, fluoride, cyanide, sulfate, and hexavalent chromium.

8. Radioactive species including gross alpha and beta by gas proportional detection; tritium by liquid scintillation detection; total radiostrontium by gravimetric separation followed by gas proportional detection. Isotopes of plutonium, americium, and

uranium are determined by ion exchange and liquid extraction techniques followed by alpha pulse height analysis.

9. Volatile and semivolatile compounds from the EPA Contract Laboratory Program (CLP) Target Analyte List are analyzed by gas chromatography/mass spectrometry. Phenols also are analyzed using spectrophotometry. Polychlorinated biphenyl compounds are analyzed by gas chromatography.

10. Toxicity Characteristic Leaching Procedure (TCLP) extractable metals and organics for compliance to land ban restrictions.

Procedures for these analyses, developed by the General Laboratory analytical technical staff, were adopted from EPA-approved sources or from other recognized authoritative publications where EPA-approved procedures were not available. Laboratory operations procedures are documented in a standard format, approved by the manager of the Rocky Flats Analytical Laboratories, and issued to a controlled distribution list to ensure that proper testing and approval is performed before changes are adopted. The Analytical Laboratories Quality Assurance Plan requires annual review of procedures for consistency with state-of-the-art techniques and compliance of laboratory practice with written procedures. In addition, a review is performed whenever an analytical problem is indicated.

Analytical Procedures

Water samples to be tested for chemical and physical parameters are preserved and/or refrigerated, when required. The tests performed include gravimetric, titrametric, calorimetric, chromatographic, or electroanalytical methods, following procedures specified in the 17th edition of *Standard Methods for the Examination of Water and Waste Water, Methods for Chemical Analysis of Water and Wastes*, EPA-SW846, or other authoritative publications.

All water samples analyzed for radioactive materials, except those scheduled for tritium analysis, are acidified immediately upon collection.

Liquid samples received for gross alpha and beta screening are evaporated, and the residue is electroplated on planchets for gas proportional counting. When activities exceed action guidelines, notification is made, and reanalysis and/or investigation may be required.

Tritium is measured using liquid scintillation counting. Counting efficiency is determined using a separately prepared vial to which is added a known standard tritium activity.

Strontium is radiochemically separated from the sample matrix using precipitation techniques. Strontium is deposited on planchets with a carrier element, and the activity in the sample is quantified using beta gas proportional counting.

For some liquids such as machine oils, a specified volume is evaporated, ashed, and the salt residue is taken up in nitric acid for deposition onto the counting planchet. A correction factor is determined for each sample to account for self-absorption effects.

Water samples to be analyzed for metal ions are preserved with nitric acid and are digested before being analyzed by atomic absorption or inductively coupled plasma (ICP) methods. Organic toxic species are determined by Gas Chromatograph/Mass Spectrometry/Data Systems following EPA protocol for volatile organics and semivolatile organics. Some organics, such as phenol, are determined by developing achromaphoric complex and measuring light absorption at a specific wavelength with a spectrophotometer. Measuring occurs after extraction into an appropriate solvent phase.

DETECTION LIMITS AND ERROR TERM PROPAGATION

Radioactivity Parameters

RH Laboratories have adopted the following definition for detection limit, as given by Harley (HA72):

"The smallest amount of sample activity using a given measurement process (i.e., chemical procedure and detector) that will yield a net count for which there is confidence at a predetermined level that activity is present."

The minimum detectable amount (MDA) is the term used to describe the detection limit and is defined as the smallest amount of an analyzed material in a sample that will be detected with a "β" probability of non-detection (Type II error), while accepting an "α" probability of erroneously detecting that material in an appropriate blank sample (Type I error). In the formulation below, both α and β are equal to 0.05.

Based on the approach presented in draft ANSI Standard N13.30, *Performance Criteria for Radiobioassay* (HE85), the formulation of the MDA for radioactive analyses is:

$$MDA = \frac{4.65\ S_B + 2.71/(T_S E_S Y)}{aV}$$

where S_B = standard deviation of the population of appropriate blank values (disintegrations per minute, d/m)

T_S = sample count time (minutes, m)

E_S = absolute detection efficiency of the sample detector

Y = chemical recovery for the sample

a = conversion factor (disintegrations per minute per unit activity) (a = 2.22 disintegrations per minute per picocurie [dpm/pCi] when MDA is in units of pCi and a = 2.22 x 10^6 disintegrations per minute per microcuries [dpm/µCi] when MDA is in units of µCi)

V = sample volume or weight (V=1 if the MDA per sample is desired)

The major component of the MDA equation is the variability of the blanks.

Table D-1 shows the various formulas used for alpha data reduction during 1991. Table D-2 shows the typical MDA values for the various analyses performed by the RFP Laboratories. These values are based on the average sample volume, typical detector efficiency, detector background, count time, and chemical recovery. MDA values calculated for individual analyses may vary significantly depending on actual sample volume, chemical recovery, and analytical blank used.

There are distinct changes in several detection limits reported for 1991 environmental analyses. A significant factor for these changes was the conversion of blank population statistical assessment and control to a "trimmed mean" approach (Encyclopedia of Statistical Science, Volume 9, Wiley and Sons, 1988). In the trimmed mean approach, a current population of blanks used to correct analytical results is limited to 20 blanks. What results is basically something between a moving average and a moving mean, which handles the non-Gaussian blank population more appropriately and is more responsive to current trends in the laboratory.

Another factor, particularly for uranium-234, -238 analysis, is the change from use of uranium-236 to uranium-232 as an internal chemical yield monitor. The uranium-232, although possessed of a troublesome shorter half-life, has less intrinsic uranium-234, -238 contamination, resulting in a lower population blank and less variability with attendant MDA improvement.

Table D-1

Formulas for Activity and Uncertainty Calculations for the Alpha Spectral Analysis Systems

<u>Non-Blank Corrected Sample Activity</u>

$$A_{si} = \left[\frac{\dfrac{C_{si}}{T_s} - \dfrac{C_{Bi}}{T_B}}{\dfrac{C_{sj}}{T_s} - \dfrac{C_{Bj}}{T_B}}\right] \frac{D_{sj}}{V \,.\, 2.22}$$

<u>Blank Corrected Sample Activity</u>

$$B_{si} = A_{si} - A_{ri}$$

<u>Non-Blank Corrected Sample Uncertainty*</u>

$$a_{si} = A_{si} \left[\frac{\dfrac{C_{si}}{T_s2} + \dfrac{C_{Bi}}{T_B2}}{\left[\dfrac{C_s}{T_s} - \dfrac{C_{Bi}}{T_B}\right]^2} + \frac{\dfrac{C_{sj}}{T_s2} + \dfrac{C_{Bj}}{T_B2}}{\left[\dfrac{C_{sj}}{T_s} - \dfrac{C_{Bj}}{T_B}\right]^2} \right]^{1/2}$$

<u>Blank Corrected Sample Uncertainty</u>

$$b_{si} = (a_{si}2 + a_{ri}2)\ 1/2$$

*Sample uncertainty is the propagated standard deviation of sample activity using counting statistics.

A_{ri} = Nonblank corrected activity of laboratory reagent blank for isotope i expressed as picocuries (pCi) per unit volume.
a_{ri} = Nonblank corrected uncertainty of laboratory reagent blank expressed as pCi per unit volume.
A_{si} = Sample activity for isotope i expressed as pCi per unit volume.
a_{si} = Sample activity uncertainty expressed as pCi per unit volume.
B_{si} = Blank corrected sample activity for isotope i expressed as pCi per unit volume.
b_{si} = Blank corrected sample uncertainty expressed as pCi per unit volume.
D_{sj} = Activity (dpm) of internal standard isotope j added to sample.
C_{si} = Sample gross counts for isotope i.
C_{sj} = Sample gross counts for internal standard isotope j.
C_{Bi} = Detector background gross counts for isotope i.
C_{Bj} = Detector background gross counts for internal standard isotope j.
T_s = Sample count time expressed in minutes.
T_B = Detector background count time expressed in minutes.
V = Sample unit volume or sample unit weight.

Table D-2
Typical Detection Limits for Radioactive and Nonradioactive Materials

Parameter	Minimum Detectable Activity (per sample)	Approximate Sample Volume Analyzed[a]	Minimum Detectable Activity (per unit volume or mass)
Airborne Effluents			
Plutonium-239,-240	5.9×10^{-8} µCi	7,340 m^3 [b]	0.008×10^{-15} µCi/ml
Uranium-234	1.3×10^{-7} µCi	7,340 m^3 [b]	0.018×10^{-15} µCi/ml
Uranium-238	1.4×10^{-7} µCi	7,340 m^3 [b]	0.020×10^{-15} µCi/ml
Americium-241	4.3×10^{-8} µCi	7,340 m^3 [b]	0.006×10^{-15} µCi/ml
Tritium (H-3)	2.1×10^{-6} µCi	1.4 m^3	$1{,}530 \times 10^{-15}$ µCi/ml
Beryllium	2.5×10^{-1} µCi	7,340 m^3 [b]	3.0×10^{-5} µg/m^3
Ambient Air Samples			
Plutonium-239,-240	9.7×10^{-8} µCi	29,000 m^3 [c]	0.003×10^{-15} µCi/ml
Effluent Water Samples (Radioactive)			
Plutonium-239,-240	8.1×10^{-8} µCi	1,000 ml	0.81×10^{-10} µCi/ml[c]
		7,000 ml	0.12×10^{-10} µCi/ml[c]
Uranium-234	0.15×10^{-6} µCi	1,000 ml	0.15×10^{-9} µCi/ml[c]
Uranium-238	0.15×10^{-6} µCi	1,000 ml	0.15×10^{-9} µCi/ml[c]
Americium-241	6.2×10^{-8} µCi	1,000 ml	0.62×10^{-10} µCi/ml[c]
		7,000 ml	0.089×10^{-10} µCi/ml[c]
Tritium (H-3)	2.1×10^{-6} µCi	10 ml	2.14×10^{-7} µCi/ml[c]
Soil Samples (Radioactive)			
Plutonium-239, -240	0.03 pCi/gm	1-5 gm	
Effluent Water Samples (Nonradioactive)			**Minimum Detection Limit**
pH		100 ml	0-14 SU
Nitrates as N		4 ml	0.02 mg/l
Total Phosphorus		50 ml	0.01 mg/l
Biochemical Oxygen Demand, 5-Day		300 ml	5.0 mg/l
Suspended Solid		100 ml	4.0 mg/l
Total Chromium		100 ml	0.01 mg/l
Residual Chlorine		10 ml	0.1 mg/l
Oil and Grease		1,000 ml	0.5 mg/l
Fecal Coliform Count		100 ml	1 colony/100 ml
Total Organic Carbon		5 ml	5.0 mg/l

a. Volume analyzed is usually an aliquoted fraction of the total sample volume collected.
b. Monthly composite.
c. Composite of 2 biweekly samples.

Nonradioactivity Parameters

For nonradioactivity parameters, various means are used to estimate a minimum detection limit (MDL) depending on the parameter measured. MDL is defined as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte. The MDL for beryllium in effluent air, analyzed using flameless atomic absorption spectroscopy, is based on a sample blank absorbance reading. Total chromium in effluent water samples undergoes a fourfold concentration of the received sample prior to its analysis using flame atomic absorption spectroscopy. Its approximate MDL is based on a net sample absorbance reading of 0.010.

The parameters of nitrate as N, total phosphorous, suspended solids, oil and grease, and total organic carbon have MDLs determined by procedural methods found in EPA-600, *Environmental Monitoring and Support Laboratory, Methods for Chemical Analysis of Water and Wastes* (EPA87b). Biochemical oxygen demand and pH have MDLs determined by the minimal readout capability of the instrumentation that is used. The MDL for residual chlorine is determined by the procedure found in a publication by Hach Company, *DPD Method for Chlorine* (HA83). For fecal coliform count, MDL is calculated as 4.65 times the standard deviation of the blank value from the millipore filter.

REPORTING OF MINIMUM DETECTABLE CONCENTRATION AND ERROR TERMS

Plutonium, uranium, americium, tritium, and beryllium measured concentrations are given in this report. Most of the measured concentrations are at or very near background levels, and often there is little or no amount of these materials in the media being analyzed. When this occurs, the results of the laboratory analyses can be expected to show a statistical distribution of positive and negative numbers near zero and numbers that are less than the calculated minimum detectable concentration for the analyses. The laboratory analytical blanks, used to correct for background contributions to the measurements, show a similar statistical distribution around their average values. Negative sample values result when the measured value for a laboratory analytical blank is subtracted from a sample analytical result that is smaller than the analytical blank value. Results that are less than calculated minimum detectable levels indicate that the results are below the level of statistical confidence in the actual numerical values. All reported results - including negative values and values that are less than minimum detectable levels - are included in any arithmetic calculations on the data set. Reporting all values allows all of the data to be evaluated using appropriate statistical treatment. This assists in identifying any bias in the analyses, allows better evaluation of distributions and trends in environmental data, and helps in estimating the true sensitivity of the measurement process.

The reader should use caution in interpreting individual values that are negative or less than minimum detectable levels. A negative value has no physical significance. Values less than minimum detectable levels lack statistical confidence as to what the actual number is, although it is known with high confidence that it is below the specified detection level. Such values should not be interpreted as being the actual amount of material in the sample, but should be seen as reflecting a range from zero to the minimum detectable level, in which the actual amount would likely lie. These values are significant, however, when taken together with other analytical results that indicate that the distribution is near zero.

Error terms in the form of a±b are included with some of the data. For a single sample, "a" is the analytical blank corrected value; for multiple samples, "a" represents the average value (arithmetic mean). The error term "b" accounts for the propagated statistical counting uncertainty for the sample and the associated analytical blanks at the 95 percent confidence level. These error terms represent a minimum estimate of error for the data.

METRIC FRACTIONS

Multiple	Decimal Equivalent	Prefix	Symbol
10^6	1,000,000	mega-	M
10^3	1,000	kilo-	k
10^2	100	hecto-	h
10	10	deka-	da
10^{-1}	0.1	deci-	d
10^{-2}	0.01	centi-	c
10^{-3}	0.001	milli-	m
10^{-6}	0.000001	micro-	μ
10^{-9}	0.000000001	nano-	n
10^{-12}	0.000000000001	pico-	p
10^{-15}	0.000000000000001	femto-	f
10^{-18}	0.000000000000000001	atto-	a

METRIC CONVERSION TABLE

Multiply	By	Equals	Multiply	By	Equals
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft
ac	0.404	ha	ha	2.47	ac
mi	1.61	km	km	0.621	mi
lb	0.4536	kg	kg	2.205	lb
liq. qt. - U.S.	0.946	l	l	1.057	liq. qt. - U.S.
ft^2	0.093	m^2	m^2	10.764	ft^2
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.31	ft^3
d/m	0.450	pCi	pCi	2.22	d/m
pCi/l (water)	10^{-9}	μCi/ml (water)	μCi/ml (water)	10^9	pCi/l (water)
pCi/m^3 (air)	10^{-12}	μCi/cc (air)	μCi/cc (air)	10^{12}	pCi/m^3 (air)

TRADITIONAL AND INTERNATIONAL SYSTEMS OF RADIOLOGICAL UNITS

(Traditional units are in parentheses.)

Quantity	Name	Symbol	Expression in Terms of Other Units
absorbed dose	Gray	Gy	J/Kg^{-1}
	(rad)	rad	10^{-2} Gy
activity	Becquerel	Bq	1 dps
	(curie)	Ci	3.7×10^{10} Bq
dose equivalent	Sievert	Sv	J/Kg^{-1}
	(rem)	rem	10^{-2} Sv
exposure	Coulomb per kilogram		C/Kg^{-1}
	(roentgen)	R	2.58×10^{-4} C/Kg-1